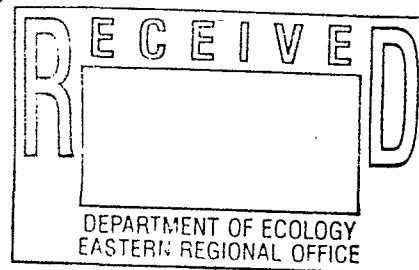


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An Evaluation of the Fisheries Potential
of the Lower Spokane River: Monroe
Street Dam to Nine Mile Falls Dam

Investigator: Todd R. Kleist

Environmental Affairs Department,
The Washington Water Power Company
and the
Washington State
Department of Wildlife

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ABSTRACT

A preliminary fisheries investigation was undertaken in a cooperative effort between The Washington Water Power Company and the Washington State Department of Wildlife. The purpose of the study was to assess the existing fishery of the lower Spokane River and Nine Mile Reservoir, WA via benthic food-base composition and abundance; composition and relative abundance of existing fish populations; diet, age, and growth of salmonid species; and habitat characters. Benthic densities were dominated by Hydropsyche sp. (caddisflies) and Baetis sp. (mayflies) with maximums occurring at Station 6 (\bar{X} #/M²=2,941, \bar{X} g(dry)/M²=4.047) and at Station 7 (\bar{X} #/M²=79, \bar{X} g(dry)/M²=0.225) respectively in the lotic portion of the study area. Nine Mile Reservoir was dominated by chiromomidae (true flies) (\bar{X} #/M²=682, \bar{X} g(dry)/M²=0.175) and oligochaeta (worms) (\bar{X} #/M²=335, \bar{X} g(dry)/M²=0.140). Rainbow trout (Salmo gairdneri) dominated the catch in the lotic portion while bridgelip suckers (Catostomus catostomus) were the predominant species in the reservoir. The stomach contents of three different salmonid species were examined. Numerically, rainbow trout (n=14), brown trout (Salmo trutta) (n=6), and mountain whitefish (Prosopium williamsoni) (n=3) fed predominately on Hydropsychidae (46.2%), Hydropsychidae (30.6%), and Chironomidae (80.3%) respectively. The rainbow trout sample was dominated by 2+ and 3+ aged fish. Annual growth increments appeared to be somewhat less than those found in the Snake River, WA, but at or greater than growth comparisons made nationally. Habitat indicators suggested that the lower Spokane River provides marginal to good habitat for juvenile and adult salmonids, but appears to be extremely limited in the aspect of spawning habitat. Nine Mile Reservoir provides excellent shoreline cover but is composed principally of silt and sand for bottom substrate thus providing poor conditions for most gamefish.

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INTRODUCTION

The 15.9 mile stretch of the lower Spokane River, WA occurring between Monroe Street Dam (RM 74.0) (Table 1) and Nine Mile Falls Dam (RM 58.1) is a largely unexplored section of the river in terms of its present or potential use as a fishery. The waters have not been routinely stocked or monitored by the Washington State Department of Wildlife (WSDW) (formerly the Washington State Department of Game) but have received intermittent allotments of rainbow trout (Salmo gairdneri), brown trout (Salmo trutta), and eastern brook trout (Salvelinus fontinalis) amounting to an excess of one million fish stocked since 1948 (Appendix A). Consequently, very little is known as to what extent the stocking efforts have contributed to the relative abundance of the species present. Previous researchers have indicated a high diversity of fish inhabiting the Spokane river based on research and creel surveys (Table 2) (Bailey and Saltes 1982; Anderson and Soltero 1984). Pfeiffer (1985) described an apparent equal abundance of squawfish and catostomids in Nine Mile Reservoir.

The potential may exist to consciously manage the lower Spokane River as a sport fishery. To address this potential, The Washington Water Power Company (WWP) and the WSDW established a cooperative study to initiate data collection and compilation. The objectives of this study were thus to establish baseline information on the composition and abundance of food organisms and fish species, age and growth structure of existing salmonid populations, summer diet of salmonids, and habitat features available.

DESCRIPTION of STUDY AREA

The Spokane River, Spokane, WA originates in Idaho as an effluent of Lake Coeur d'Alene. The discharge of the river is controlled largely by tributary inflows and the operation of Post Falls Dam by the WWP (Bailey and Saltes 1982). Gaining several cubic feet of water, the mean annual flow of the Spokane River at Monroe Street Dam is 6,849 cfs (Zentz 1983). Between Monroe Street and Nine Mile Falls Dams, flows of the river are augmented by: 1) Hangman Creek, a tributary entering at RM 72.4 and contributing a mean flow of approximately 200 cfs (USGS, 1985; 1986; 1987); 2) the effluent from Spokane's Advanced Wastewater Treatment Facility (AWT) entering at approximately RM 67.3 and contributing a mean annual discharge of 51.52 cfs +/- 3.07 (AWT 1986; 1987); and 3) Deep (a.k.a. Cedar) Creek, an intermittent stream, entering at RM 59.0 with no flow data available. However, throughout the duration of the study no water entered from the creek. Springs and/or groundwater seepage was observed entering the river: 1) from the hillside bordering Pettet Drive and the river at approximately RM 69.9, extending along approximately 100 M of shoreline; and 2) at approximately RM 65.2 where a small spring was observed issuing from the northern shoreline. These springs appeared to be minor contributors to flow during the study period but may have a greater impact during periods of high runoff.

The portion of the Spokane River that was the focus of this project extended from Monroe Street Dam (R43E, T25N, S12; RM 74.0) downstream to Nine Mile Falls Dam (R42E, T26N, S6; RM 58.1) (Figure 1) a total of 15.9 miles.

At the initiation of the project in June 1987, the study area was largely divided into two rather distinct sections. The first was that portion which exhibited sequences of riffles, runs, and pools, characteristic of a lotic system. This section stretched from Monroe Street Dam downstream approximately 10.1 miles (to RM 63.9) where the last set of riffles was observed (determined at a flow of 2200 cfs (USGS 1987)). The second portion extended the remaining 5.8 miles to Nine Mile Falls Dam, representing the water impounded by the dam and having created Nine Mile Reservoir.

Nine Mile Reservoir functions as a run-of-river type of dam operation producing 4,600 acre-ft of pondage occupying a maximum area of 420 acres with a drawdown potential of 16.6 feet (Zentz 1983). The shoreline of the reservoir is dominated by grasses, shrubs, and trees which often overhang the water. The uppermost end of the reservoir consists of a substrate with a predominance of boulders which then quickly recedes downstream to a predominance of silts, loams, and sands. Two bays occur (RM 60 and 61) that harbor the only observed aquatic macrophytes, Elodea sp. and Ceratophyllum sp.

The study area was further subdivided into the following nine sites to facilitate benthic sampling (Figure 2):

Station 1, Maple Street Bridge; access from south side of the river off of Water Street; riffle, 30 cm in depth, a substrate mix of medium (20%) and large (80%) cobble.

Station 2, Above Hangman Creek; access from west side of the river via People's Park; site approximately 60 M upstream of confluence; riffle, 30 cm in depth, a substrate mix of large cobble (30%) and boulder (70%).

Station 3, Below Hangman Creek; access from east side of river off of Ohio Street; site approximately 300 M downstream of confluence; riffle, 30 cm in depth, a substrate mix of large cobble (50%) and boulder (50%).

Station 4, T. J. Meenach (Fort George Wright) Bridge; access from north side of the river, Riverside State Park dirt road; riffle, 30 cm in depth, a substrate mix of medium (80%) and large (20%) cobble.

Station 5, Above AWT; access from south side of river via dirt road surrounding the Riverside Convalescent Center; riffle, 30 cm in depth, a substrate mix of small (20%) and medium (80%) cobble.

Station 6, Below AWT; access from north side of the river over the hillside at the western most end of Spokane's Advanced Wastewater Facility; site approximately 200 M downstream of water pipe bridge crossing; riffle, 30 cm in depth, a substrate mix of large cobble (70%) and boulder (30%).

Station 7, Terminal Lotic Site; access from north side of the river approximately 500 M downstream of the Spokane Riffle Club, trail down to river; riffle, 30 cm in depth, a substrate mix of large cobble (70%) and boulder (30%).

Station 8, Seven Mile Bridge (RM 61.9); access by boat from private boat launch owned by Mr. and Mrs. George Nesbitt, located at the intersection of Seven Mile Road and Aubrey L. White Parkway; deep station, mid-channel, 5 M in depth, predominately silt (10%) and sand (90%); shallow station, shoreline, 2 M in depth, predominately silt (30%) and sand (70%) with sparse cobble and boulder.

Station 9, Overhead Powerlines (RM 60.8); access by boat from same location as Station 8 but 1.1 miles downstream; deep station, 5 M in depth, predominately silt (30%) and sand (70%); shallow station, shoreline, 2 M in depth; predominately silt (40%), sand (50%), organic detritus (10%) with sparse cobble and boulder.

METHODS and MATERIALS

Benthos/Zooplankton-Collection

Benthic samples were taken from nine sites (Figure 2). In the reach between Monroe Street Dam and RM 63.9 where conditions were lotic in nature, samples were collected from riffles less than 30 cm in depth using a Surber sampler (900 cm², 1 Ft²) (Lind 1979). Riffles are a good indicator of a stream's productivity and are most often sampled to determine the abundance of aquatic organisms (Needham and Needham 1962). Hynes (1970) also notes that benthic invertebrate numbers and biomass are typically higher at the edges of large streams (greater than 7 M wide) than at the center due to differences in current velocity and availability of shelter. Time and equipment restrictions prevented sampling areas other than near-shore riffles.

At each station, the water temperature was taken, the dominate substrate was numerically described (Table 3), and three replicate benthic samples were taken at 1 M intervals starting downstream for the first sample (Weber 1973; Lind 1979) and working upstream to complete the second and third. Numeric descriptions of the substrate were based on a decimal system utilized by Bovee (1982).

Actual collection of invertebrates required complete, or near complete, denuding of the area within the frame of the sampler. Large rocks occurring within the frame of the sampler were scrubbed of organisms at the mouth of the net and the exposed substrate was then disturbed to a depth of 5-10 cm by hand or a metal rod (Platts, *et al.* 1983). Collected samples were placed in a white enamel pan to permit sorting while organisms were alive (Weber, 1973; Platts, *et al.* 1983). Each of the individually sorted replicates were then preserved in 10% formaldehyde.

Samples taken from the two Nine Mile Reservoir stations (Figure 2) consisted of a deep and a shallow site. All samples were taken from an anchored boat where deep station sampling was initiated with a temperature profile from the surface to the bottom at 1 M intervals. A bottom to top vertical zooplankton tow was also made at each deep station with a Wisconsin style zooplankton net (80 um mesh). The retrieved net was rinsed and collected organisms were preserved and stained as described by Lind (1979). Benthic

samples were made using an Ekman dredge (200 cm^2 , 0.25 ft^2) lowered to the bottom. Three replicate samples were made at each station, both deep and shallow, with each sample being passed through a number 30 mesh sieve (Lind 1979). Organisms were picked from the mesh and preserved in 10% formaldehyde (Lind 1979) and considered a pooled sample of three replicates.

Zooplankton were identified to the lowest possible taxonomic level using the keys of Pennak (1979) and Needham and Needham (1962). Three-two milliliter subsamples were enumerated and identified from each of the original concentrated tow samples. Abundance was expressed as numbers per liter.

Benthic/Zooplankton-Analysis

Benthic organisms were examined using either a Baush and Lomb Stereozoom binocular dissecting or an American Optical Forty binocular dissecting scope and identified to the lowest possible taxonomic level using the keys of Needham and Needham (1969), Pennak (1978), and Merritt and Cummins (1984). Organisms were enumerated for each replicate, mean numbers per group, standard deviations, variances, and abundance ($\bar{X} \text{ \#}/M^2$) were calculated (Platts, *et al.* 1983).

Replicate samples were pooled for each sample site to be dried for biomass determination. Foil cups were made from 5 x 5 cm square pieces of commercial foil (Bowen 1983) and were preweighed to the nearest one thousandth of a gram on a Mettler Type H8 electronic balance. Organisms were placed in the foil cups, blotted dry of preservative, and placed in a Thelco 31472 (Precision Scientific Co.) drying oven for four hours at 105°C (Weber 1973; Platts, *et al.* 1983). Cases and shells of organisms having such structures (e.g., trichopterans and gastropods) were removed from the organisms prior to drying and thus eliminated from the biomass estimation (Needham and Needham 1969). At the completion of the drying period the samples were again weighed, the difference representing the dry weight of a particular taxonomic group. Dry weights less than 0.001 grams were considered trace (T) amounts.

Crayfish (Astacidae)-Collection

Crayfish (Astacidae) trapping was conducted in various habitat types from the T. J. Meenach Bridge (RM 69.8) downstream to Seven Mile Road Bridge (RM 61.9) using five Gees G 40 CF crayfish traps on two separate set lines. One line had three traps spaced at three meter intervals and the second had two traps spaced by three meters. Traps were baited with dead fish (rainbow trout, brown trout, sucker, or squawfish) and were set for a minimum of 22 hours which included both light and dark periods. Captured crayfish were enumerated and measured for total length from the tip of the rostrum to the tip of the median uropod (Anderson and Gutreuter 1983).

Crayfish-Analysis

Data was interpreted in terms of presence or absence in a given location, the catch per unit effort (CPUE) was determined when applicable, and mean sizes were determined.

Fisheries-Collection

The primary means of fish data collection in the river portion of the study area was hook-and-line followed by boat electrofishing, collection from anglers, or with a Smith-Root pulsed DC portable backpack shocker. Collection within Nine Mile Reservoir was primarily done via a boat mounted boom electrofishing unit, followed by graded mesh gillnets (60 M x 2 M) set perpendicular to shore, hook-and-line, and collection from anglers. Each fish collected was identified to the species level using the key of Wydoski and Whitney (1979), measured for maximum total length to the nearest millimeter, (Weber, 1973) and a scale sample taken for later age determination (salmonids only). Occasionally a stomach sample was taken for diet analysis (salmonids only) with the intent of sampling all size classes throughout the summer.

Scales collected from all salmonid species were removed from a location dorsal to the lateral line and ventral to the anterior edge of the dorsal fin using a knife drawn against the scales towards the head (Jearld 1983). Scales were then placed in coin envelopes and labeled as to date, location, species, and length.

Stomachs were collected by opening the body cavity with scissors and cutting the intestinal tract just posterior to the pyloric sphincter and then cutting the esophagus at its most anterior portion (Bowen 1983). Extracted stomachs were then placed in 10% formaldehyde for later examination. At the time of stomach removal, the sex and degree of sexual maturity (immature, mature, ripe, or spent) was determined based on apparent gonadal development.

Fisheries-Analysis

Composition and Relative Abundance

The composition of fish species present was evaluated in terms of the species encountered during field collections, examination WSDW stocking records, and synoptic species lists compiled by previous researchers.

Relative abundance was evaluated on the basis of species distributions in field collections and relative comparisons of catch per unit effort (CPUE).

Age and Growth

Collected scales were temporarily mounted between glass slides and viewed with a Vantage III microform reader. Age was determined by counting the number of annuli present in the anterior field of the scale; regenerated scales were discarded (Jearld 1983).

Since scale growth is proportional to the growth in length of the fish itself, annual growth was estimated utilizing the collected scales (Lux 1971). Back calculations were calculated by measuring the distance from the focus to each subsequent annulus and the outer margin along the longest radius of any particular scale (Lux 1971, Everhart and Youngs 1981, Jearld 1983). Measured distances were then entered into the equation:

$$L^1 = (S^1/S) \times L \quad \text{eq (1)}$$

where L^1 is the estimated length at the time of annulus formation for annulus X; S^1 is the length of the scale radius to annulus X; S is the length of the total scale radius; and L is the length of the fish at the time of sampling (Everhart and Youngs 1981). A linear growth pattern was assumed throughout, hence no allowance or corrective factor for growth prior to scale formation was applied. Back calculated lengths were then averaged by age class and standard deviations determined.

Diet

Previously collected stomachs were opened with scissors, the contents emptied into a petridish and examined using an American Optical Forty binocular dissecting scope. Aquatic organisms were identified to the lowest taxonomic level practicable. Bowen (1983) suggests that identification to the family level is quite adequate. Terrestrial organisms were identified similarly, but were consolidated into "Terrestrial" food items for ease of reporting. Organisms were then enumerated. Partially digested or disarticulated organisms were accounted for by only counting a hard structure (i.e., head capsule) (Pillay 1952, Bowen 1983). Organic (e.g., vegetation, seeds, etc.) and inorganic (gravel, fishhooks, etc.) material was only noted as to presence or absence.

Evaluation of Habitat

Pool/Riffle Ratio

The pool-to-riffle ratio is the length or percent of riffle divided into the length or percent of pool (Platts et al. 1983). This ratio allows a means of providing limited predictability of a stream's ability to furnish adequate areas for resting, feeding, and spawning of fish and food production. Theoretically, equal portions of each habitat type provide the optimum conditions.

For the purpose of this study, pools and runs were considered to be equivalent since they are not easily distinguishable in the Spokane River. Bailey and Saltes (1982) also noted that the reaches in the upper Spokane River did not conform to normal sequences of riffles, runs, and pools. Runs and pools were not easily distinguishable since the areas expressed characteristics of both pools and runs. By combining these two habitat types, the best possible index value was then established. Making the distinction between runs and pools would further decrease the value of the denominator and the result would be a lower index value.

Portions of the water column where water velocity was fast, stream depths relatively shallow, and the water surface gradient was relatively steep, were identified by definition to be riffles (Platts et al. 1983) and were normally confirmed by a turbulent surface. Anything not appearing as riffle was considered to be a pool. On-site measurements were made at the shoreline/water interface between Monroe Street Dam (RM 74.0), disregarding the cascade immediately below the dam, and the T. J. Meenach Bridge (RM 69.8); and between approximate RM 65.5 and the upper end of Nine Mile Reservoir (RM 63.9) (Figure 3).

Accessibility prevented measurements from both shorelines of most riffles. Thus one measurement was taken that was considered to be representative of the total length of the riffle.

Discharge

Instream flow measurements were obtained from the United States Geological Survey (USGS) for the stations "Spokane at Spokane, WA" (1966-1987) and "Hangman Creek, Spokane, WA" (1985-1987) and from daily dam operation logs of Monroe Street Dam and Nine Mile Falls Dam (WWP 1987). Areas where undocumented inflow occurred were also noted.

Annual discharge summaries were examined as they apply to the quality of trout habitat. Two methods were utilized to relate the discharge of the Spokane River to the theoretically corresponding available and useable habitat. Each method attempts to model the flow data based on previously compiled data from several different systems. The first, known as the "Montana" or the "Tennant Method", was devised by Tennant (1975) as a means of determining flow regimes to protect aquatic resources. Recommendations were empirically derived, based on physical, chemical, and biological data collected between 1964 and 1974 in three states, from 11 different streams at 38 different flows. Further analyses in 21 states over 17 years allowed Tennant to substantiate his findings and correlate with a variety of streams (Bayha 1978). Tennant's curve data thus represented varying degrees of resource potential in terms of the habitat parameters of width, depth, velocity and their consequent contributions toward the wetted perimeter. Data generally suggested that instantaneous flow regimes approximating 10% of the average annual stream flow provided minimum short-term survival habitat; 30% of the average annual stream flow provided good survival habitat; and 60% of the average annual flow provided excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreation uses (Tennant 1976). Tennant further recommended flow percentage goals for specific time frames on an annual basis: A minimum instantaneous flow 20% of the average annual flow from October through March and 40% from April through September provides for satisfactory conditions; 40% of the average annual flow from October through March and 60% from April through September provides for excellent fishery flows; similar distributions at 60 and 100% of the average annual flow then provides for optimum fishery conditions (Bayha 1978).

The second method, presented by Raleigh et al. (1984), utilizes the same principles as Tennant but expresses a slightly modified method for interpreting flow data and consequently, modified criteria for interpreting the results. Raleigh et al. suggest that as the difference between base flow (the lowest annual flows usually occurring during late summer and early fall) and the average annual flow increases, the quality of trout habitat decreases. Suggested criteria states that a base flow of greater than 50% of the average annual flow is considered excellent for maintaining quality trout habitat, 25-50% is considered to be fair, and less than 25% considered to be poor.

Riparian Vegetation and Cover

Characteristic vegetation and its relative extent of distribution occurring along the shoreline throughout the study area was noted during field data collections. Observations of types and apparent quality of cover were also noted.

Channel Morphology

Sinuosity is an index used to classify a stream's channel pattern and is defined as the ratio between channel length between any two points and a straight line distance between the same two points (Bovee 1982, Platts et al. 1983). The value is useful for gross comparisons of aquatic habitat conditions. In general, low sinuosity (near 1) suggests a steeper channel gradient, fairly uniform cross section shapes, limited bank cutting, and limited pools. High sinuosity (near 4) is associated with lower gradients, asymmetrical cross sections, overhanging banks, and bank pools on the outside of curves (Platts et al. 1983).

Sinuosity was estimated using USGS (1986, 1986, 1986) topographic maps of the area and a map wheel were one mile increments between study area boundaries were measured three times each and an average determined for each one mile segment of river.

Channel gradient is defined as the drop in water surface elevation per unit length of channel and is an important variable in regulating stream velocity. Gradient was estimated using USGS (1986, 1986, 1986) topographic maps of the area (20 foot contour interval) and a map wheel. Three measurements were made for each segment between contour interval-river intersections and averages determined for each segment.

Temperature

Water temperature determinations were made at each benthic site (a single measurement at riffle sites and a vertical temperature profile at each deep reservoir station) and longitudinal temperature profiles were made at selected sites throughout the study area (Figure 4). Longitudinal temperature determinations were made during July and August as data was collected sequentially from sites starting at Station 1. Subsequent readings at downstream stations were made as rapidly as possible, limited by travel time.

Potential Spawning Locations

Potential salmonid spawning sites were evaluated during the same field examination period as pool-to-riffle ratio data collection and thereby incorporated the same areas (Figure 3). Suitable spawning substrates were primarily noted as to presence or absence but was not quantified as to the area incorporated. Substrates were visually inspected primarily near shore-lines (to depths of water that permitted vision to the bottom) and dewatered areas below high water marks. Therefore, observations may not reflect the substrate occurring in the mid-channel and/or deep water. Characteristic sites and particle sizes were evaluated according to optimal spawning conditions for rainbow trout as described by Raleigh et al. (1984) and brown trout (Raleigh et al. 1986).

RESULTS and DISCUSSION

Benthos/Zooplankton

Composition and Abundance

Mean numbers (per M^2) and biomass (\bar{X} g(dry)/ M^2) distributions by sample station are located in Tables 4 and 5. The general abundance and biomass of organisms tended to increase downstream from Station 1 to Station 7 (Figure 5). The typical substrate size and abundance was medium cobble (10%) and large cobble (90%) from Station 1 to 7. The fauna was represented by several taxonomic groups but was numerically dominated by the families Hydropsychidae and Baetidae. The vast majority of the numeric and biomass distribution was contained in the family Hydropsychidae. These are collector organisms that filter organic matter from the water column with their silken nets. They tend to occur in areas below reservoirs or where there is an abundance of particulates (Needham and Needham 1962). Numerically, the second most abundant taxonomic group was the family Baetidae. These organisms are considered scrappers, obtaining food from the algae and other organics adhering to the substrate surfaces.

The noted downstream increases coincide with point sources of inflow that contain, or likely contain, increased amounts of nutrients or particulates. The first notable increase of benthic organisms occurred at Station 3 (Figure 5), below the confluence of Hangman Creek. The Hangman Creek drainage basin includes large areas of cultivated land and likely contributes nutrients from agricultural runoff during certain periods of the year and may contribute to the increased abundance observed.

The second most noteworthy point is located at Station 6 where a considerable increase in both numerical abundance and biomass occurs. Station 6 occurs below the AWT effluent which contains suspended organic particulates readily useable by the Hydropsychidae. Hydropsychidae are represented in quantities per square meter two times higher than any station upstream and constitute about 82% of the total estimated biomass at the station. The observed increase can most likely be attributed to the AWT outfall that apparently enhances their habitat.

Beyond Station 6, relative values decrease in comparison yet remain well above all stations upstream to Station 6. The decrease may be a result of upstream utilization of nutrients, deposition, and/or dilution of the particulates. Station 7, however, does represent the greatest abundance of Baetidae (Table 4).

Deep (DP) and shallow (SH) stations 8 and 9 within Nine Mile Reservoir (Figure 2) express a highly reduced diversity of organisms yet support relatively high numbers of organisms within a taxonomic group. The data suggest that oligochaetes and chironomids dominate the bottom fauna throughout the reservoir. This is consistent with Pfeiffer (1985) who made the same conclusions after studying the same reservoir. However, data further suggests that total numbers of organisms are greatest at the initiation of the reservoir and gradually decrease as one continues downstream.

It is generally considered that macrobenthos species compositions are a reflection of environmental conditions based on their tolerances to constituents found in the water and substrate. Hence data has been compiled that describes an organism's tolerances to selected materials and consequently formulates indicator species or communities. No analysis or comparisons were made during this project, but Appendix B contains a summary of species found to inhabit the lower Spokane River relative to different types of environmental influences.

Zooplankton found to be inhabiting Nine Mile Reservoir were only present in extremely low numbers and included rotifera, cladocera, and copepoda. Station 8 was found to include Keratella sp. (4.14/L), Bosmina sp. (4.14/L), and nauplii (4.14/L), and copepoda (8.11/L). Station 9 was found to include Bosmina sp. (0.17/L) and nauplii (0.32/L). It is clear that zooplankters are not in excess and calculations suggest that zooplankter abundance does not constitute an available food source.

Due to the low retention time as suggested by the limited storage capacity (4,600 ac-ft) and mean annual flow of 7,996 cfs (Zentz, 1983), there is apparently little time for zooplankter populations to develop and consequently they only appear in low numbers. Factors that may be attributed to the decreased benthos densities may be the relative high amount of sedimentation as compared to upstream sites and therefore sufficient habitat is not provided that would lend itself to support an abundant and diverse bottom fauna. Secondly, field and laboratory observations indicate relatively low primary productivity within the reservoir as only limited aquatic macrophytes exist and phytoplankton species were not observed in zooplankton samples.

Crayfish (Astacidae) Trapping

While conversations with anglers and patrons spending large amounts of time at or near the river suggested that crayfish are present in the lotic portion of the study area (Herron, pers. comm.), no crayfish were encountered over a total set time of 70.5 hours (Table 6). However, crayfish were relatively abundant in Nine Mile Reservoir, appearing in catches at both sites sampled. Catch per unit effort ranged from 0.26 to 1.95 and produced crayfish with mean total lengths of 112.9 mm (range 93-130) and 126.4 mm (110-154) respectively. The interpretation of mean total length needs to be qualified in that the particular traps used and the locations that they were set may have inadvertently introduced some degree of sampling bias. Such bias is suggested since the smallest crayfish encountered measured 93 mm, far larger than early juvenile life stages.

It is safe to say, however, that there are crayfish present in the lower end of the river and on into the reservoir and may therefore be available as a food source for predatory fish species.

Fisheries

Composition and Relative Abundance

The composition of fish sampled consisted of a rather high diversity of salmonids, cyprinids, catostomids, cottids, and percids (Table 2), with salmonids dominating the catch (Table 7) in the lotic portion and catostomids

dominating the catch in the reservoir (Table 8). Compiled WSDW stocking records (Appendix A) indicate that an excess of one million salmonids have been introduced into the system since 1948 and may be a major contributor to the observed distributions. Exact locations of the plants were not available. In addition, upstream (i.e., Idaho) stocking efforts may also provide recruitment to the lower Spokane River. High numbers of northern squawfish were not encountered as previously reported (Pfeiffer 1985).

Catch per unit effort was calculated based on hook-and-line sampling and suggested that rainbow trout were present, or at least caught, about three times as often as brown trout when using bait or lure (Table 7) between RM 74.0 and RM 63.9. In comparison to CPUE values reported by Bailey and Saltes (1982) which ranged from 0.05 to 0.579 during 1980 and 1981 at both high and low flows, the lower Spokane River was considerably higher at 0.92 for all species considered. Rainbow trout caught outnumbered nongame fish 3:1 within this reach. Only one westslope cutthroat was caught in a total of 65.5 angler hours and are therefore not thought to be very abundant. Mountain whitefish were only encountered in one short section of the river at RM 63.9 while electrofishing and were not caught at all on hook-and-line.

Large numbers of cyprinid and catostomid fry were observed through most of the summer months along the shoreline shallows throughout the entire study area. Limited excursions with the backpack shocking unit revealed low numbers, less than 5%, of rainbow trout fry in comparison to all species encountered.

Age and Growth

A total of 38 rainbow trout, 13 brown trout, 1 westslope cutthroat, and 3 mountain whitefish scale samples were collected with hook-and-line, from angler catches, electrofishing and with gillnets throughout the entire study area (Table 9). A total of 12 nongamefish were caught on hook-and-line in the lotic portion of the study area while 75 nongame, predominately bridgelip suckers, and 1 game fish (yellow perch) were encountered during electrofishing collections in Nine Mile Reservoir (Table 8). No age and growth data were taken on nongamefish with the exception of maximum total lengths (Table 8).

Scale data analysis indicated that there was a predominance of 2+ and 3+ rainbow trout in the catch, 17 and 13 respectively, followed by 1+ and 4+ fish with four representatives each. These data, in comparison to Bailey and Saltes (1982) suggest that a greater proportion of the population is made up of the 2+ and 3+ age classes of fish rather than a 1+ denomination. A major consideration in this interpretation, however, is the difference in the sampling method and the number of samples taken. Hook-and-line is biased to sample the catchable sizes and may therefore not select the smaller 1+ or 0+ fish. An alternative interpretation of the data suggests that the predominance of the population enters the fishery at the 2+ and 3+ age class and size. Bailey and Saltes's represents a much less biased method and a much larger sample for interpretation of population structure.

Back calculation analysis suggested that rainbow trout growth was quite uniform from one age class to the next with the highest annual growth rate occurring during the third season (2+) of growth (Table 11). Lengths at annulus formation compare favorably with other northwest states (Table 12).

The Snake River expresses a much higher growth rate beyond the second annulus formation as compared to Spokane River rainbows. This observation may be largely a factor of river size. General field observations indicated that all rainbow trout sampled were healthy fish containing substantial amounts of body fat.

Brown trout were the second most frequently encountered salmonid species (Table 9). Scale analysis revealed only two age classes, 2+ and 3+, in the samples, numbering eight and five respectively.

Determination of backcalculated total lengths was omitted from the analysis since the sample size was extremely low and the majority of the growth of these fish might represent growth attained while in residence at hatcheries rather than in the Spokane River system.

Age analysis of mountain whitefish and westslope cutthroat (3+, 340 mm) was limited to only three and one individual, respectively. Mountain whitefish were represented by three different age classes (0+, 135mm; 2+, 255mm; 3+, 327mm). Here too, a small sample size prevented adequate back calculation analysis.

Diet

Of the 25 stomach samples taken, none were found to be empty and most contained organisms that indicated a mix of both very little and a rather high degree of digestion had taken place on ingested food items. For these reasons, all species of salmonids appeared to be feeding through most of the day prior to capture.

Generally, the food of rainbow trout in streams consists mostly of aquatic (principally caddisflies, mayflies and dipterans) and terrestrial insects, zooplankton and fish though their relative importance varies between waters and seasons (McAfee 1966, Carlander 1969). Species taken at a greater frequency than their abundance on the bottom are those that are active crawlers or swimmers, fairly large species, or species on exposed positions of rocks (Carlander 1969). The summer diet of Spokane River rainbows is quite consistent with descriptions provided by Carlander. Hydropsychidae was the predominant food organism consumed by all age classes, accounting for 46.2% of the total meal in the 14 stomachs sampled (Figure 6). Baetidae and chironomidae were the next most prevalent food items at 17.3% and 11.5% respectively. These organisms are either exposed and/or swimming organisms or, in the case of chironomidae, were often eaten during transient pupal stages. Terrestrial insects played a relatively minor role in the diet, amounting to only 6.4% of the total meal and included Formicidae, Ichneumonidae, Coleopterans and Arachnids. Organic detritus occurred in 50% of the stomachs examined and included aquatic moss, seeds, sticks, and corn. For the convenience of data presentation, food items occurring at a frequency of less than 1% were grouped as "other" and included: Naididae (0.7%), Physidae (0.1%), Hemiptera (0.3%), Nematoda (0.1%), Simuliidae (0.2%) and Osteichthyes (0.5%). Proportions of aquatic organisms in the diet approximated the relative proportions found in the benthic samples.

Due to a small sample size, diet breakdown of rainbow trout by age class was omitted from results and discussion. However, the diet breakdown by species and age class can be found in Appendix C. Piscivory was only observed in the 4+ age class and amounted to 2.6% (Appendix C). Yet, hook-and-line sampling with 50-100 mm bait fish (cyprinids and catostomids) produced rainbows ranging from 224-426 mm in length which suggests that fry may be a food source utilized by several age classes when fry are available. Both crayfish and fish, mostly *Cottus* species, were fairly important food items in Michigan streams for trout 178-406 mm, and the major foods of those 430-711 mm (Carlander 1969). Fish that occurred in the 4+ rainbows were not sculpins but were either cyprinids or catostomids. Diet analysis of a small sample size for only the summer season may not be indicative of what occurs on an annual basis.

Brown trout are generally considered opportunists that will consume a wide range of aquatic and terrestrial insects, crustaceans, and other invertebrates (Staley 1966, Carlander 1969). Larger individuals may feed more extensively on fish (Staley 1966, Carlander 1969). Hydropsychidae was the predominant food item consumed by all brown trout in the Spokane River, accounting for 30.6% of the total meal in the six stomachs sampled. Chironomidae and other dipterans comprised the next most prevalent food organisms, 14.2% and 15.3% respectively. Terrestrial insects accounted for 7.1% of the diet (Figure 6) and included the same groups previously indicated for rainbow trout. Piscivory was observed in the 2+ age class (Appendix C) and also in one individual (385 mm) of an undetermined age. Piscivory accounted for 1.6% of the meal for all brown trout considered. Organic detritus occurred in 3 of the 8 stomachs examined and included aquatic moss, seeds, and twigs.

Mountain whitefish feed primarily on aquatic insects, chiefly bottom organisms with trichoptera, ephemeroptera, plecoptera, and diptera predominating. Terrestrial insects may be eaten when bottom fauna is sparse. Whitefish will occasionally consume Annelids, Gastropods, crayfish, young fish, and eggs of its own species and others (Carlander 1969). In this study, Chironomidae was by far the most highly consumed food organisms in the three whitefish stomach samples taken, comprising 80.3%. Hydropsychidae and Tipulidae were the next most abundant food organisms, occurring in 7.5% and 7.2% of the meal respectively (Figure 6).

The food habits thus described for the lower Spokane River are highly consistent with those described by Baily and Saltes (1982). They used an index of selectivity to describe feeding habits of salmonids and found statistically significant selectivity for *Hydropsyche* sp., *Asellus* sp., and *Baetis* sp. Of these organisms, *Asellus* sp. was not encountered in either benthic samples (Table 4) or stomach samples (Figure 6). However, both other groups were numerically important food items in the lower Spokane River.

Carlander (1969) reported that the effect of impounded water on brown trout feeding habits resulted in Entomostraca and terrestrial insects becoming more important dietary items, and sometimes fish, as the bottom fauna decreased.

Only two stomach samples were collected in Nine Mile Reservoir. The diet contained 64.7% Chironomidae, 17.6% other dipterans, and 17.6% osteichthyes (Figure 7). These data are fairly consistent with reported findings with the exception of terrestrial insects, of which none were found.

Evaluation of Habitat

Pool/Riffle Ratio

Pool-to-riffle ratios were calculated at flows ranging between 620 and 910 cfs from 8-25-87 to 8-27-87 (WWP 1987). Segment 1 maintained a ratio of 2.3, 43% of the distance being riffle and segment 2 maintained a ratio of 3.0, 25% of the distance being riffle. Values were calculated from on-site measurements that constituted 57% of the lotic portion of the study area (Figure 8).

These values suggest that there is approximately 2.3 to 3.0 times as much pool-run type of habitat than riffle at lower flows. Theoretically, the amount of riffle habitat would further decrease at higher flows. Raleigh et al. (1984) indicate that a ratio of 1.0 is optimum for rainbow trout habitat.

Discharge

Flow data was evaluated from USGS flow records (1966-1967 and 1969-1986 inclusive). The mean base flow, as defined by Raleigh et al. (1984), over a 20 calendar year period was 995 cfs +/- 307. The average annual daily flow, calculated as the mean of the mean annual flows, for the same time period was 6719 cfs +/- 1867 (calendar year) and 6673 +/- 2186 (water year), while the 93-year mean (1891-1984) was 6862 cfs. Both Tennant (1975 and 1976) and Raleigh et al. (1984) have suggested that a relationship exists between these parameters and the quality of aquatic habitat.

Examination of the Spokane River discharge records using the Montana method (Table 12) indicates that, on an annual basis, an average of 80 daily flows per water year are below the 30% of average annual flow value established by Tennant (1975 and 1976) to provide for good survival habitat. On a seasonal evaluation, based on Tennant's recommendation of 20% of the average annual flow for October through March to provide satisfactory conditions, the flows of the Spokane River average less than one daily flow below these criteria. However, the average number of daily flows below satisfactory criteria (40% of average annual flow) between April and September was 79, with a maximum of 107 in 1977 and a minimum of 60 in 1974. According to the criteria of this method, the most critical flow period in the Spokane River is during the summer months. This incorporates the portions of salmonid life cycles where fry are emerging (early summer), growing (mid-summer), and adult brown trout are preparing to spawn (October). During these critical flow periods, habitat may be further influenced by other environmental factors such as temperature.

According to the method presented by Raleigh et al. (1984), the 20-year mean percent of annual base flow to the average annual daily flow (6862 cfs) (Figure 13) was 15 +/- 5, with a one-year high of 24% and a low of 7%. This suggests that the Spokane River experiences large swings between high and low annual flows and consequently offers aquatic organisms varying habitat conditions. The impact of these flows regimes may be compounded if base flows occur at or near critical life stages of trout species (i.e. spawning, incubation, or emergence) that are unable to physically adjust to fluctuating

environmental conditions. This analysis of average conditions suggests that wide variability in flows is an inherent characteristic of the Spokane River drainage basin. Certainly, run-of-the-river hydroelectric projects further influence this situation, but how operations could be changed to moderate these conditions is beyond the scope of this assessment.

Riparian Vegetation and Cover

Willows, grasses, and shrubs constituted the majority of the riparian vegetation occurring along the 15.9 miles of the study area. The upper 10.1 miles had sparse areas of such vegetation and provided little to no shoreline cover, during the lower seasonal flows of the study period. In many cases the absence of stream side vegetation can be attributed to the dynamics of flood plain transitions created by the river or the steep and/or rocky terrain through which the river flows. These conditions may limit the quantity and quality of the riparian vegetation that can inhabit these areas. Existing vegetation occurred at or near the high water mark. Instream vegetation consisted of one small area of Elodea sp. in a backwater area upstream of Maple Street Bridge and an aquatic moss of undetermined species that occurred only in riffle habitats. In this section of the river, it appeared that the available cover was dominated by water depth, surface turbulence, and abundant, large instream substrate.

In contrast, the shoreline of Nine Mile Reservoir was dominated by the above mentioned vegetation which was often overhanging and/or in the water. Undercut banks were frequently available for cover in some reaches of shoreline where deeply rooted vegetation occurred. In areas where extensive root systems were not present, undercut banks appeared to have slumped and deposited loams and silts. Occasional slow water areas of the reservoir contained holdings of partially submerged logs, brush, and debris that may be available for cover. Beds of aquatic vegetation (Elodea sp. and Ceratophyllum sp.) that occurred in the reservoir appeared to be the primary source of cover utilized in shallow water by the fish species present based upon results of, and observations during, electrofishing data collection.

Channel Morphology

Between the boundaries of the study area, the mean index value for sinuosity was 1.4 (Table 14). This suggests that the Spokane River supports a steeper gradient channel and fairly uniform cross sectional shapes and offers limited pools. This supports the field observation that definite pools are not common in this area of the river and further explains the lack of shoreline cover (i.e. bank cutting). The average channel gradient between the boundaries of the study area was 0.52%. The highest gradient (2.4%) occurs from Monroe Street Dam to Maple Street Bridge and then decreases rapidly (Table 15).

Temperature

Due to limited temperature data collection, no interpretations or correlations were made. Available data is located in Appendix D.

Potential Spawning Locations

During the examination of potential spawning area, discharges ranged from 620 cfs to 910 cfs (Figure 8). At these flows, areas where adequate substrate and habitat type considered to be optimal for both rainbow and brown trout spawning to occur were very few. Areas that did contain sufficient gravels occurred on the downstream side of large objects (i.e. concrete slabs, boulders, etc.) or were located in dewatered areas which would be watered under higher flow conditions. One point that was noted was that extremely large objects (i.e. railroad trestle piers and bridge piers) tended to accumulate sands and fines, not quality substrate. Upon close examination, areas that did not have suitable substrates were often dominated by medium cobble, large cobble, and/or boulders. The interstices did appear to contain adequate particle sizes but embeddedness appeared high, suggesting that these areas get scoured at higher flows. Occasionally the interstices did contain loose gravels but these areas would theoretically restrict the size of spawning fish capable of accessing them.

The locations that seemingly had the greatest potential for spawning were located between RM 69.8 and 74.0. An area located between the Sans Souci West Mobile Home Park and the T. J. Meenach Bridge had the smallest average particle sizes, comprised mostly of large gravels and small cobble. Additionally, deposits of large gravel were observed along the shorelines where springs were found to be issuing (see Description of Study Area).

Two additional areas, one between RM 72.6 and 74.0 and the other in the vicinity of benthic station 5, appear to contain small holdings of mixed gravels and cobbles.

Habitat Summary

Optimal riverine trout habitat is characterized by clear, cold water; a silt-free, rocky substrate in riffle-run areas; an approximately 1:1 pool-to-riffle ratio, with areas of slow, deep water; well vegetated stream banks; abundant instream cover; and relatively stable water flow, temperature regimes, and stream banks (Raleigh and Duff 1980). The upper 10.1 miles of the study area approximates much of the above mentioned criteria. However, the aspects of vegetated stream banks, instream cover, water flow, and, in part, pool-to-riffle ratios appear to be less than optimum conditions.

Cover is recognized as one of the essential components of trout streams. Cover is provided by overhanging vegetation; submerged vegetation; undercut banks; instream objects, such as debris piles, logs, and large rocks; pool depth; and surface turbulence (Giger 1973). Adult brown trout seek cover more than any other trout species; a cover area greater than or equal to 35% of the total stream is adequate (Raleigh *et al.* 1986). Adult rainbow trout require less cover, greater than or equal to 25%, while juveniles only require 15% or more (Raleigh *et al.* 1984). Furthermore, some studies suggest that the number and weight of trout are positively correlated to the amount of cover and that adding or subtracting cover from a system will alter the population and biomass structure (Raleigh *et al.* 1986). Streamside vegetation provides potential cover and may promote the introduction of organic matter and terrestrial food items (Raleigh *et al.* 1984). In addition, vegetated stream banks help to control watershed erosion which, in turn, reduces the amount of fines entering the system.

Large variations in flow regimes constitute a fluctuating environment. The impact of this is most likely realized by organisms not physically capable or readily adapted to respond (i.e. sessile or juveniles). This may affect the fish populations directly or indirectly by disrupting the aquatic invertebrate populations (see Gislason 1985).

Pools are important as a refuge from adverse conditions during the winter (Raleigh et al. 1984). Riffles generally provide the bulk of the aquatic invertebrate food base (provide well oxygenated conditions) and turbulence for cover. Therefore a ratio of 1:1 is considered optimal and is a typical characteristic in trout streams having the greatest production (Raleigh et al. 1984). However, streams or reaches of streams having high ratios as well as streams having ratios as low as 0.4:1 have been reported as high producers of salmonids (Platts et al. 1983). As it appears, the Spokane River may be a representative of the former.

To what extent that these apparent deficiencies affect the fisheries or whether the favorable conditions mask their impact could not be determined. However, management or improvements directed to these aspects may have the greatest potential of supplementing the fishery in this reach of the Spokane River.

CONCLUSIONS AND RECOMMENDATIONS

My personal thoughts of the system are that there exists a good fishery with great potential for an economically beneficial salmonid fishery in the lower Spokane River. However, there appears to be limiting factors, primarily relating to natural recruitment, that if gone unchecked could result in a decreased fishery if fishing pressure and consequent harvest were to increase. I base my judgement on the observations of limited spawning areas, the apparently low success of spawning and consequent fry survival, and through discussions with anglers that indicate angler pressure has been recently increasing.

I feel that the primary focus for future research or management plans should be at the spawning life stage. It appears that there exists adequate cover (i.e. medium cobble, large cobble, and boulders) throughout the majority of the river to provide refuge and escape cover for emerged salmonid fry if spawning is successful.

The requirements of salmonids for spawning are quite variable both within and between species but common criteria has been assembled in order to assess a given area (See Raleigh et al. (1984) and Raleigh et al. (1986) for rainbow and brown trout respectively).

In comparing the spawning requirements of the two salmonids of greatest relative abundance in the lower Spokane River, rainbow and brown trout, there exists a major difference. Rainbow trout have to have their requirements met primarily in the late winter and early spring months, although strains exist which are capable of spawning nearly any month (Raleigh et al. 1984). In contrast, brown trout requirements need to be met during early and late fall.

These periods during the year present vastly different flow regimes in the Spokane River and consequently results in quite different habitats that are both available and useable (this is assuming that spawning is restricted to the river). This difference may be very influential on the success or failure of either species over time and should be a consideration in management decisions.

Spawner surveys, redd counts, and surveys of types and quality of substrates would lend more detailed knowledge to the need for, direction, and/or extent of habitat improvement, should it be deemed necessary. Artificial spawning channels are a sophisticated means of improving or creating proper habitat and has reportedly increased total survival to 91%, well above the customary 10% natural survival (Everhart and Youngs 1981). Spawning habitat can also be improved with less costly approaches such as dumping quantities of appropriate substrate sizes in likely areas (Everhart and Youngs 1981). As previously noted (see Potential Spawning Locations), areas of the Spokane River that contained adequate particle sizes were often located behind objects that reduced scouring. Introducing moderate sized objects (large objects tended to accumulate fines) may be a promising enhancement option.

The collection of additional information pertaining to the seasonal food-base utilization, dynamics of population abundance and distribution, angler harvest and natural mortality, and aspects of water quality and quantity would further supplement existing knowledge and would lend to the formulation of prudent management policies. All of these aspects provide useful information necessary in the successful management of a fishery resource.

To address these areas and provide direction for future research, I would suggest that the following topics be considered:

I. Habitat

Identification and quantification of useable spawning habitats would provide the necessary information to direct structural improvements in the river. These may incorporate spawning channels, retaining structures, or increasing the abundance of spawning gravels by dumping quantities of appropriate particle sizes into the river. Determination of useable spawning habitat can be accomplished via spawner surveys and/or redd counts followed up by emergence and fry counts. A consideration for such surveys is the time of year and characteristic flows of the river. Fry and juvenile winter survival counts would likely be the most successful for both species in question and may be the most useful. Redd counts may only be reasonable for fall spawning brown trout since high flow patterns restrict access to rainbow spawning sites in the spring.

Additional habitat considerations would include a monitoring program of water quality parameters and annual discharges. Baseline water quality becomes quite useful and especially important if there is concern of upstream activities that may have downstream impacts.

II. Population Dynamics

The above mentioned fry and juvenile counts are entirely applicable from a population perspective as well. Supplemental population information can be collected through snorkel surveys and creel surveys which may express trends in abundance or angler pressure and provide support for regulatory actions.

Aspects of the seasonal diet of the salmonid populations should be another consideration along with any quantification of the general health of individual (i.e., condition factors).

Together, the accumulation of any or all of these aspects can only serve to promote the fishery and should be part of future management decisions.

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Landmark	River Mile
Spokane River	
Monroe Street Bridge	74.0
Maple Street Bridge	73.6
Stream Gauge, USGS #12422500	72.9
Old Union Pacific Railroad Grade	72.6
Hangman Creek	72.4
Old Great Northern Railroad Grade	71.5
T.J.Meenach (Fort George Wright) Bridge	69.8
Seven Mile Road Bridge	61.9
Deep Creek	59.0
Nine Mile Dam (normal pool)	58.1
Hangman Creek	
Hangman Creek Stream Gauge, USGS #12424000	00.8

Table 1. River mile (RM) locations of selected Spokane River landmarks throughout the study area (Hydrology Subcommittee 1964).

Bailey and Saltes (1982)

Rainbow Trout (*Salmo gairdneri* Richardson)
Eastern Brook Trout (*Salvelinus fontinalis* Mitchill)
Kokanee (*Oncorhynchus nerka* Walbaum)
Cutthroat Trout (*Salmo clarki* Richardson)
Yellow Perch (*Perca flavescens* Mitchill)
Pumpkinseed (*Lepomis gibbosus* Linnaeus)
Longnose Sucker (*Catostomus catostomus* Forster)
Longnose Dace (*Rhinichthys cataractae* Valenciennes)

Anderson and Soltero (1984)

Rainbow Trout
Eastern Brook Trout
Brown Trout (*Salmo trutta* Linnaeus)
Cutthroat Trout
Sunfish
Yellow Perch
Walleye (*Stizostedion vitreum vitreum* Mitchill)
Northern Squawfish (*Ptychocheilus oregonensis* Richardson)
Bullhead
Suckers

Pfeiffer (1985)

Northern Squawfish
Suckers
Brown Bullhead (*Ictalurus nebulosus* Lesuer)
Black Crappie (*Pomoxis nigromaculatus* Lesuer)
Yellow Perch
Largemouth Bass (*Micropterus salmoides* Lacepede)
Mountain Whitefish (*Prosopium williamsoni* Girard)
Carp (*Cyprinus carpio* Linnaeus)

Current Study (1987)

Rainbow Trout
Brown Trout
Cutthroat Trout
Mountain Whitefish
Redside Shiner (*Richardsonius balteatus* Richardson)
Northern Squawfish
Chislemouth (*Acrocheilus alutaceus* Agassiz and Pickering)
Longnose Dace
Speckled Dace (*Rhinichthys osculus* Girard)
Piute Sculpin (*Cottus beldingi* Eigenmann and Eigenmann)

Table 2. Summary of fish species encountered in the Spokane River system as determined through creel surveys and research.

Numeric Code	Substrate Description
1	Organic Detritus
2	Fines (sand and Smaller)
3	Small Gravel (4-39 mm)
4	Large Gravel (39-75 mm)
5	Small Cobble (75-150 mm)
6	Medium Cobble (150-225 mm)
7	Large Cobble (225-300 mm)
8	Boulder (>300 mm)
9	Bedrock

Table 3. Numeric codes and descriptions of substrate particle sizes used in benthic substrate evaluation (Brusven Index, modified from Bovee 1982).

STATION	Trichoptera (early instar)	Hydropsyche	Cheumatopsyche	Oncomeris	Dicosmoecus	Rhyacophila	Glossosomatidae	Baetis	Chironomidae	Antocha	Simuliidae	Paragyracis	Perlodidae	Optioservus	Naididae	Physidae	Nematoda	TOTALS
ST1/6-29-87																		
Ambient High 33.0 C																		
Ambient Low 17.9 C																		
Ambient Mean 25.8 C																		
Water Temp. 17.1 C																		
Mean Flow (cfs) 1340																		
Total Organisms		80				1	1		69	30			4		8			307
Mean number of Organisms		23.3				10.3	0.3		23	10			1.3		2.7			
Variance		538.2				0.3	0.3		5.2	6.8			2.3		4.4			
+/- S.D.		23.2				0.6	0.6		2.7	2.6			1.5		2.1			
Mean Number/sq. M		250.7				3.2	3.2		247.5	107.6			14		29.1			1067.4
g(dry)/sq. M		0.908				0.025	0.004		0.032	0.057			0.004		0.165			1.313
ST2/6-29-87																		
Ambient High 33.0 C																		
Ambient Low 17.9 C																		
Ambient Mean 25.2 C																		
Water Temp. 18.8 C																		
Mean Flow (cfs) 1340																		
Total Organisms		221						82	15	10	8				3	1		340
Mean Number of Organisms		73.7						27.3	5	3.3	2.7				1	0.3		
Variance		5476						408	6.8	2.3	6.3				2.9	0.3		
+/- S.D.		74						20.2	2.6	1.5	2.5				1.7	0.6		
Mean Number/sq. M		793						293.7	53.8	35.5	29.1				10.8	3.2		1291.1
g(dry)/sq. M		2.156						0.083	0.011	0.022	0.007				0.136	0.022		2.437
ST3/6-30-87																		
Ambient High 35.8 C																		
Ambient Low 14.6 C																		
Ambient Mean 25.2 C																		
Mean Flow (cfs) 1190																		
Total Organisms		230		1		6		76	33	29	1				16	1	2	394
Mean Number of Organisms		76.7		0.3		2		25.3	11	9.7	0.3				5.3	0.3	0.7	
Variance		161.3		0.3		4		44.9	25	0.3	0.3				8.4	0.3	1.4	
+/- S.D.		12.7		0.6		2		6.7	5	0.6	0.6				2.9	0.6	1.2	
Mean Number/sq. M		825.3		3.2		21.5		272.2	118.4	104.4	3.2				57	3.2	7.5	1415.9
g(dry)/sq. M		2.372		0.072		0.042		0.061	0.004	0.072	T				0.441	T	0.004	3.068
ST4/7-1-87																		
Ambient High 35.3 C																		
Ambient Low 16.8 C																		
Ambient Mean 26.3 C																		
Water Temp. 17.4 C																		
Mean Flow (cfs) 1430																		
Total Organisms		229		1		4		98	12	57			2		8			411
Mean Number of Organisms		76.3		0.3		1.3		32.7	4	19			0.7		2.7			
Variance		670.8		0.3		5.3		121	13	27			1.4		6.3			
+/- S.D.		25.9		0.6		2.3		11	3.6	5.2			1.2		2.5			
Mean Number/sq. M		821		3.2		14		351.9	43	204.4			7.5		29.1			1474.1
g(dry)/sq. M		2.644		0.004		0.093		0.1	0.007	0.1			T		0.104			3.052

Table 4. Benthic invertebrate composition , abundance, and biomass and physical data for Stations 1-7.

STATION	Trichoptera (early instar)	Hydropsyche	Cheumatopsyche	Oncosmoecus	Dicosmoecus	Rhyacophila	Glossosomatidae	Baetis	Chironomidae	Antocha	Simuliidae	Paragyracis	Perlodidae	Optioservus	Naididae	Physidae	Nematoda	TOTALS
ST5/7-2-87																		
Ambient High 23.9 C																		
Ambient Low 14.4 C																		
Ambient Mean 19.4 C																		
Water Temp. 16.5 C																		
Mean Flow (cfs) 1490																		
Total Organisms		410	1					93	111	28			7	1	4		8	663
Mean Number of Organisms		136.7	0.3					31	37	9.3			2.3	0.3	1.3		2.7	
Variance		9722	0.3					272.3	870.3	44.9			5.3	0.3	2.3		4.4	
+/- S.D.		98.6	0.6					16.5	29.5	6.7			2.3	0.6	1.5		2.1	
Mean Number/sq. M		1470.9	3.2					333.6	398.1	100.1			24.7	3.2	14		29.1	2376.9
g(dry)/sq. M		2.372	0.007					0.093	0.043	0.047			0.011	0.004	0.151		0.004	2.732
ST6/7-6-87																		
Ambient High 22.8 C																		
Ambient Low 11.1 C																		
Ambient Mean 17.2 C																		
Water Temp. 17.2 C																		
Mean Flow (cfs) 1840																		
Total Organisms		820	1	1		3		152	22	39			5		5	16		1063
Mean Number of Organisms		273.3	0.3	0.3		1		50.7	7.3	13			1.7		1.7	5.3		
Variance		15951.7	0.3	0.3		2.9		772.8	4.4	127.7			4.4		1.4	20.3		
+/- S.D.		126.3	0.6	0.6		1.7		27.8	2.1	11.3			2.1		1.2	4.5		
Mean Number/sq. M		2940.7	3.2	3.2		10.8		545.5	78.5	139.9			18.3		18.3	57		3815.4
g(dry)/sq. M		4.047	0.007	0.122		0.054		0.176	0.007	0.069			0.072		0.007	0.359		4.916
ST7/7-9-87																		
Ambient High 19.4 C																		
Ambient Low 10.6 C																		
Ambient Mean 15.0 C																		
Water Temp. 16.9 C																		
Mean Flow (cfs) 1430																		
Total Organisms	2	368	13		4	3		236	65	52	1		1		12	11		778
Mean Number of Organisms	0.7	122.7	4.3		1.3	1		78.7	21.7	17.3	0.3		0.3		4	3.7		
Variance	1.4	3091.4	1.4		2.3	1		458	17.6	102	0.3		0.3		37.2	12.3		
+/- S.D.	1.2	55.6	1.2		1.5	1		21.4	4.2	10.1	0.6		0.6		6.1	3.5		
Mean Number/sq. M	7.5	1320.3	46.3		14	10.8		846.8	233.5	186.1	3.2		3.2		43	39.8		28008
g(dry)/sq. M	0.004	1.834	0.018		1.407	0.061		0.255	0.025	0.097			0.007		0.122	0.075		3.93
TOTALS																		
Total Organisms	2	3956	16	2	4	17	1	852	327	245	10		6	26	6	67	13	5560
Mean Number of Organisms	0.3	336.9	2.3	0.3	0.6	2.4	0.1	121.7	46.7	35	1.4		0.9	3.7	0.9	9.6	1.9	1.4
Variance	0.2	57025.4	23	0.2	2.3	4.8	0.1	3181	1332.3	252.8	8.4		3.6	24	3.6	28.1	16.8	9
+/- S.D.	0.5	238.8	4.8	0.5	1.5	2.2	0.4	56.4	36.5	15.9	2.9		1.9	4.9	1.9	5.3	4.1	3
Mean Number/sq. M	3.2	2653.1	24.8	3.2	6.5	25.9	1.1	1314.4	504.4	378	15.1		9.7	40	9.7	103.7	20.5	1517.9
% by Number	0	71.1	0.3	0	0.1	0.3	0	15.3	5.9	4	0.2		0.1	0.5	0.1	1.2	0.2	0.2

Table 4. (continued)

	Chironomidae	Oligochaeta	Hydropsychidae	Corixidae	Tipulidae	Total
ST8-DP/8-21-87 Ambient High 25.6 ^o C Ambient Low 7.2 ^o C Bottom temp. 14.4 ^o C						
Total organisms	64		1		1	66
Mean #/sq. M	918.6		14.4		14.4	974.4
g(dry)/sq. M	0.287		T		0.129	0.416
ST8-SH/8-21-87						
Total organisms	54	67				121
Mean #/sq. M	775.0	961.6				1736.6
g(dry)/sq. M	0.144	0.431				0.575
Total organisms	187	67	1		1	187
ST9-DP/8-22-87 Ambient High 27.8 ^o C Ambient Low 8.3 ^o C Bottom temp. 15.3 ^o C						
Total organisms	28	5				33
Mean #/sq. M	602.8	107.5				710.3
g(dry)/sq. M	0.100	0.014				0.114
ST9-SH/8-22-87						
Total organisms	30	19		1		50
Mean #/sq. M	430.6	272.7		14.4		703.3
g(dry)/sq. M	0.187	0.115		T		0.302
Total organisms	58	24		1		83

¹
Ambient temperature data obtained from National Weather Service, Spokane International Airport, Spokane, WA for June, July, and August, 1987.

Table 5. Summary of benthic samples taken in Nine Mile Reservoir.

Location/Date	Habitat Type	Total Hours	Time Set	Time Pulled	Catch	CPUE	Mean T.L. (mm)
T.J. Meenach Bridge 6-25 to 6-26-87	Riffle	22.5	0930	0800	0	0	0
Benthic Station 6 7-6 to 7-7-87	Riffle	25.75	1345	1530	0	0	0
Upstream (100 M) from Benthic Station 5 7-7 to 7-8-87	Pool	25.0	1545	1650	0	0	0
Benthic Station 8 8-17 to 8-20-87	Pool	68.0	1710	1315	18	0.26	112.9
Downstream (500 M) from Benthic Station 6 8-20 to 8-21-87	Pool	22.0	1500	1300	43	1.95	126.4
TOTAL		163.25			61	0.37	-
MEAN		32.7			12.2	-	122.4
+/- S.D.		19.8			18.9	-	11.4

Table 6. Crayfish trapping success from the T.J. Meenach Bridge to Seven Mile Road Bridge from 6-25-87 through 8-20-87.

Angler Hours	CPUE	Catch	Gear
	0.97	35 rainbow	Bait/Lure
	0.28	10 brown	" "
	0.03	1 cutthroat	" "
	0.17	6 squawfish	" "
36.0	1.44	52 TOTAL	Bait/lure
	0.07	2 rainbow	Fly
		2 redbside	
	0.07	shiner	"
	0.17	4 squawfish	"
29.5	0.27	8 TOTAL	Fly
65.5	0.92	60 TOTAL	ALL

Table 7. Hook-and-line summary of effort, CPUE, catch, and gear used.

Species	Electrofishing	Gillnet	Mean Total Length (mm)	% Abundance
Bridgelip sucker	56	2	298	64
Northern squawfish	8		168	9
¹ Mountain Whitefish	8		175	9
Brown trout	3	2	271	3
Longnose dace	4		85	4
Redside shiner	3		120	3
¹ Rainbow trout	3		412	3
Chislemouth	1		160	1
Yellow perch	1		194	1
TOTAL	87	4		

¹ Rainbow trout and mountain whitefish were only encountered in riffle habitat at RM 63.9.

Table 8. Summary of boat electrofishing (6 hours of operation) and gillnetting (5 hours total set time) effort in Nine Mile Reservoir from RM 63.9 to RM 59.0.

Species	Age	n=	Mean Length (mm)	Range (mm)
RBT	1+	4	233.8	222-248
RBT	2+	17	282.7	236-327
RBT	3+	13	372.6	325-412
RBT	4+	4	435.0	437-483
BRNT	2+	8	269.8	255-294
BRNT	3+	5	348.4	301-409
CUTT	3+	1	340	-
WHTF	0+	1	135	-
WHTF	2+	1	255	-
WHTF	3+	1	327	-

Table 9. Summary of the age and length distribution of salmonid species sampled throughout the study area.

Total Length (mm) at Annulus				
	1	2	3	4
n=	36	34	17	5
\bar{X}	123	219	318	397
+/- S.D.	23	30	34	18
increments	123	96	99	79

Total Length/Age at Sample				
	1+	2+	3+	4+
n=	4	17	13	4
\bar{X}	234	283	373	447
+/- S.D.	13	29	25	25

Table 10. Backcalculated lengths at annulus formation and length/age at sample for rainbow trout sampled in the lotic portion of the study area.

Location	Total Length (mm) at Annulus						
	1	2	3	4	5	6	7
Snake River, ID (Wydoski and Whitney 1979)	129.5	261.6	350.5	467.4	487.7		
Missouri River, MT (means) (Carlander 1969)	81	201	282	343	404	421	470
Montana streams (n=5144) (Carlander 1969)	84	170	251	323	363		
Alsea River, OR (n=853) (Carlander 1969)	122	163	173				
Firehole River, WY (means) (Carlander 1969)	135	234	328	396			
Madison River, WY (means) (Carlander 1969)	127	244	356	417			
Minter Creek, WA (means) (Carlander 1969)	94	137	163				
Spokane River, WA (current study 1987)	123	219	318	397			
Spokane River, ID ¹ 1985	154	245	307	354			
¹ 1986 (Bennett and Underwood 1987)	139	222	306	371			

¹ Lengths are reported as fork length at annulus rather than total length.

Table 11. Comparison of the growth rates between Spokane River rainbow trout and rainbow trout of other northwest states.

Year	Mean Annual Discharge, calendar year	Mean Annual Discharge, water year	No. of Daily Flows <10% of Average Annual Flow	No. of Daily Flows <30% of Average Annual Flow	Mean Daily Flow, Oct.-March	No. of Daily Flows <20% of Average Annual Flow	Mean Daily Flows, April-Sept.	No. of Daily Flows <40% of Average Annual Flow
1967	6571	-	2	-	5384	2	7840	89
1968	-	5222	0	85	5803	0	4640	91
1969	7466	-	0	-	-	0	-	-
1970	6436	6252	0	77	4398	0	8095	88
1971	8365	8451	0	37	5819	0	10762	64
1972	9636	9709	18	41	7558	0	11860	67
1973	4113	3394	2	118	3664	2	3126	101
1974	11630	12310	0	37	10195	6	14407	60
1975	7401	6721	0	28	3622	0	9803	65
1976	7329	8102	4	35	6407	0	9797	77
1977	3356	2508	0	155	2204	0	2810	107
1978	6077	6970	0	83	6484	0	7453	78
1979	5403	5389	0	180	3131	0	7653	88
1980	5257	4822	0	137	3250	0	6395	74
1981	6270	6477	0	89	6415	0	6537	72
1982	8335	8229	0	82	7567	0	8888	72
1983	6890	6810	0	37	6952	0	6668	59
1984	7067	7209	0	39	6097	0	8320	72
1985	5880	5740	0	90	2909	0	8556	85
1986	-	5862	0	82	6593	0	5134	100
\bar{X}			1 ± 4	80 ± 45		0.5 ± 1		79 ± 14
Mean Annual Flow, 6862 cfs (93 years, 1891-1984) Percent of Mean Annual Flow 10%, 686 cfs 40%, 2745 cfs 20%, 1372 cfs 50%, 3431 cfs 30%, 2059 cfs 60%, 4117 cfs								

Table 12. Comparative values for annual and seasonal discharges of the Spokane River from the "Spokane at Spokane" USGS gauging station using the Montana Method.

(col 1)	(col 2)	(col 3)	$\left(\frac{(\text{col } 2)}{(\text{col } 3)}\right) \times 100$	$\left(\frac{(\text{col } 2)}{6862}\right) \times 100$
Calendar Year	Minimum (base) Flow (cfs)	Mean Annual Daily Flow (cfs)	Base Flow of Mean Annual Flow (%)	Base Flow of 93 Year Mean Annual Flow (%)
1966	660	5179	19	10
1967	574	6571	15	8
1968	-	-	-	-
1969	1140	7466	14	20
1970	1070	6436	16	16
1971	1100	8365	12	16
1972	885	9636	10	13
1973	466	4113	25	7
1974	1450	11630	9	21
1975	1320	7401	14	19
1976	1630	7329	22	24
1977	523	3356	16	8
1978	1010	6077	17	15
1979	752	5403	14	11
1980	1080	5257	21	16
1981	960	6270	15	14
1982	1110	8335	13	16
1983	1110	6890	16	16
1984	1240	7067	18	18
1985	1090	5880	19	16
1986	728	5720	13	11
\bar{X}	995 ± 307	6719 ± 1867	16 ± 4	15 ± 5

Table 13. Comparison of the average annual daily flows to the minimum (base) flows (Raleigh et al 1984) of the Spokane River as they relate to rainbow trout habitat.

Approximate Location (RM)	Channel Length (mi.)	Linear Distance (mi.)	Sinuosity	Approximate Location (RM)	Channel Length (mi.)	Linear Distance (mi.)	Sinuosity
74.0	-	-	-	65.0	1.0	0.8	1.3
73.0	1.0	0.9	1.1	64.0	1.0	0.9	1.1
72.0	1.0	0.5	2.0	63.0	1.0	0.7	1.4
71.0	1.0	0.8	1.3	62.0	1.0	0.9	1.1
70.0	1.0	0.6	1.7	61.05	0.95	0.7	1.4
69.0	1.0	1.0	1.0	60.05	1.0	0.6	1.7
67.0	1.0	0.8	1.3	59.05	1.0	1.0	1.0
66.0	1.0	0.8	1.3	58.05	1.0	0.8	1.3
				\bar{X}	1.4		

Table 14. Description of channel sinuosity between study area boundaries.

Approximate Location (RM)	Elevation (feet)	% Grade of Segment	Length of Segment (miles)	Cumulative Length (miles)
74.0	1780	-	-	-
73.5	1720	2.37	0.48	0.48
72.0	1700	0.25	1.52	2.00
70.2	1680	0.22	1.76	3.76
68.0	1660	0.17	2.24	6.00
66.0	1640	0.18	2.05	8.05
64.9	1620	0.33	1.14	9.19
58.1	1600	0.06	6.71	15.90
\bar{X}	-	0.51	-	-

Table 15. Description of channel gradient between study area boundaries.

APPENDIX A

Summary of trout plants made by the WSDW in the Spokane River
(revised from Anderson and Soltero 1984).

Year	Species	Number Planted	No./lb.
1948	Rainbow Trout	5,780	5
1949	Rainbow Trout	6,280	8
1951	Rainbow Trout	6,300	6
1952	Rainbow Trout	4,500	4.5
1953	Rainbow Trout	17,660	6
1954	Rainbow Trout	9,225	1.3-4.5
TOTAL		49,745	
1974	Rainbow Trout	2,002	2.2
1976	Rainbow Trout	396,140	585-1300
1977	Rainbow Trout	347,960	4-200
	Brown Trout	2,310	21
1978	Rainbow Trout	195,278	104-110
1979	Brown Trout	5,040	21
1980	Brown Trout	5,024	32
1981	Brown Trout	5,040	12.6
1982	Rainbow Trout	470	2
	Brown Trout	5,412	13.2
1983	Brown Trout	9,652	15.2
1984	Eastern Brook Trout	2,520	3.5
1986	Brown Trout	15,978	2-5.1
1987	Rainbow Trout	197,833	2-100
	Brown Trout	7,070	2-3.5
TOTAL		1,188,077	
GRAND TOTAL		1,237,822	

Appendix B

Comparison of relative tolerances of macroinvertebrates found in the Spokane River to various types of water quality.

Macroinvertebrate	T ¹	F	I	TQ ²
Hydropsychidae				
<i>Hydropsyche</i>			x	108
<i>Cheumatopsyche</i>	x			108
Rhyacophilidae				
<i>Rhyacophila</i>			x	18
Limnephilidae				
<i>Dicosmoecus</i>				24
<i>Onocosmoecus</i>				18
Glossosomatidae				32
Baetidae	x	x	x	72
<i>Baetis</i>				72
Elmidae				
<i>Optioservus</i>		x		108
Tipulidae	x	x		72
Plecoptera			x	
Perlodidae			x	
Chironomidae	x	x	x	108
Pyralidae		x		72
Simuliidae	x	x	x	108
Nematoda		x		108
Oligochaeta	x	x		108
Naididae		x		
Physidae	x	x	x	108
Hemiptera	x			
Corixidae		x		108
Decapoda				
Astacidae	x	x	x	108

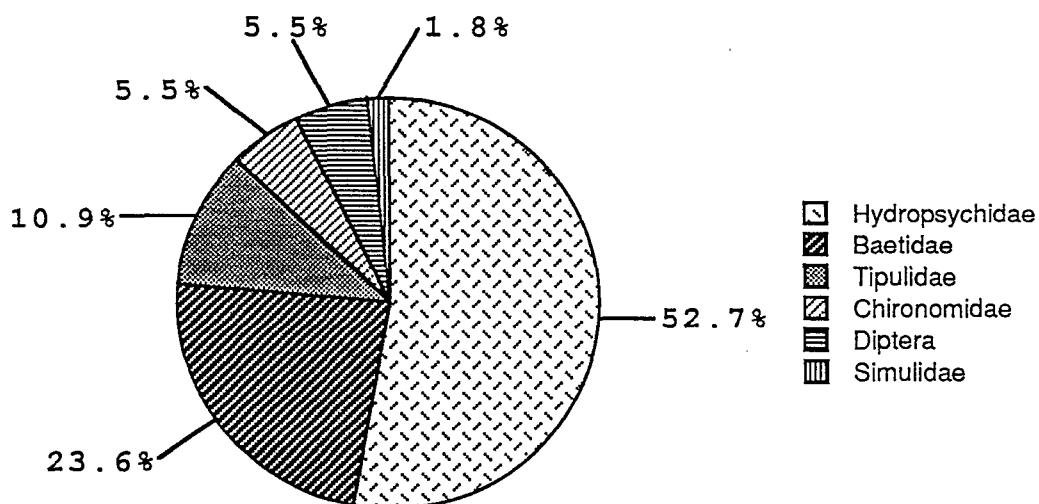
¹ General classification of the tolerances of macroinvertebrates to decomposable organic wastes (T=Tolerant, F=Facultative, I=Intolerant). (Weber 1973).

² Tolerance quotients of aquatic macroinvertebrates based upon tolerance to alkalinity, sulfate, and sedimentation including low stream gradient; values range from 2 to slightly over 100 with larger values indicating greater tolerance (Platts et al 1983).

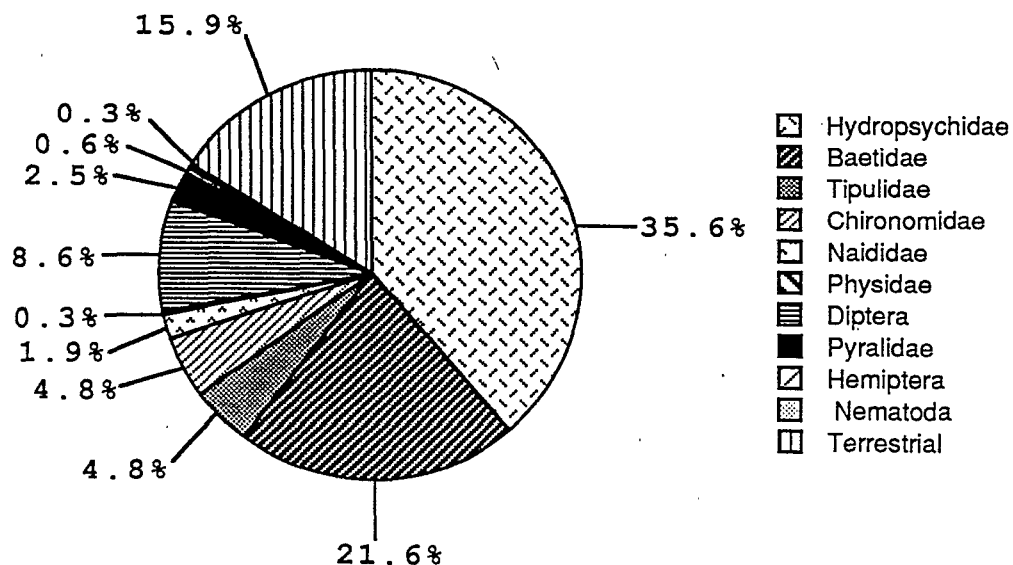
Appendix C

Summary of the diet composition by number for each age class of rainbow trout encountered in the lotic portion of the study area.

Rainbow trout, 1+ age class (n=1)

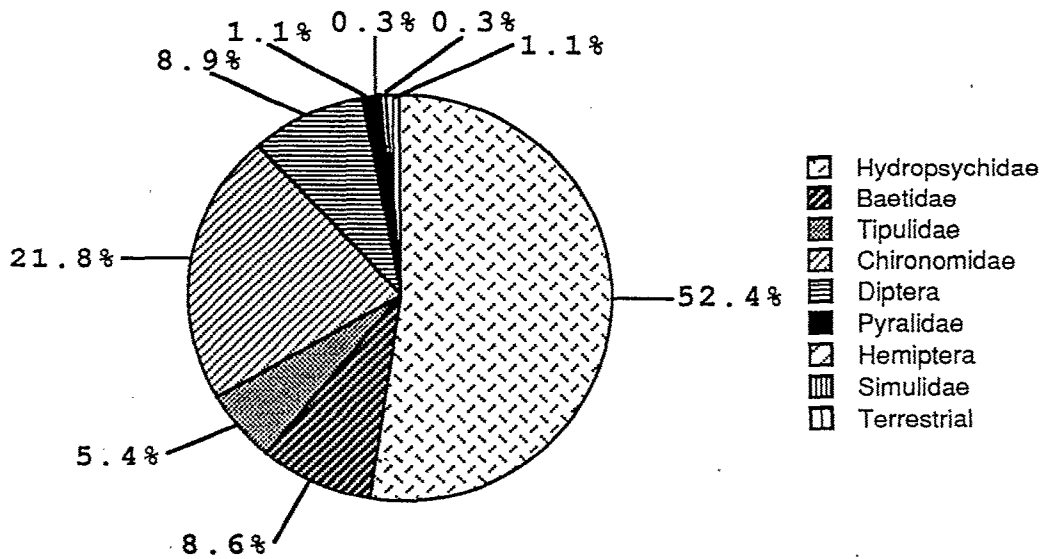


Rainbow trout, 2+ age class (n=5)

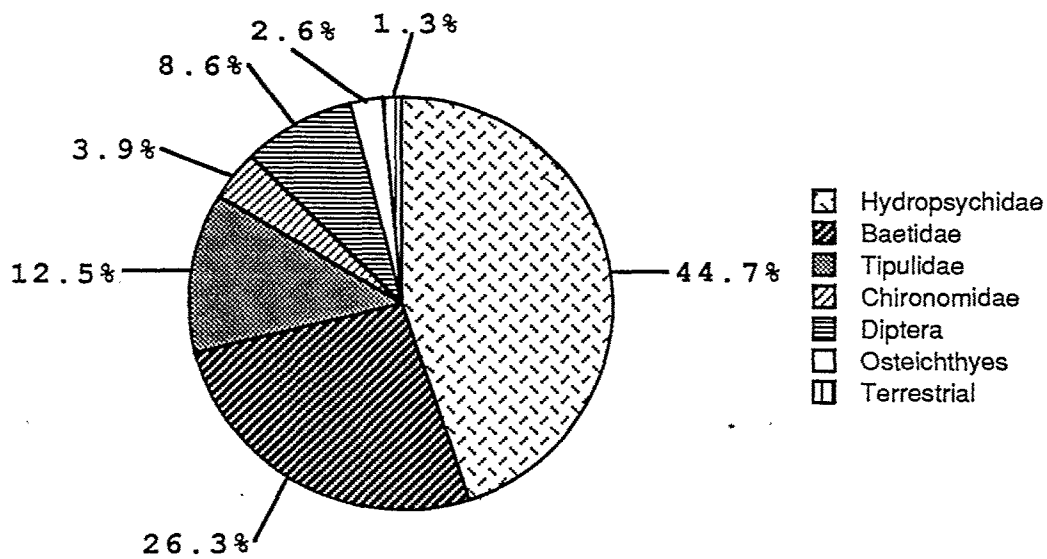


Appendix C (continued)

Rainbow trout, 3+ age class (n=6)



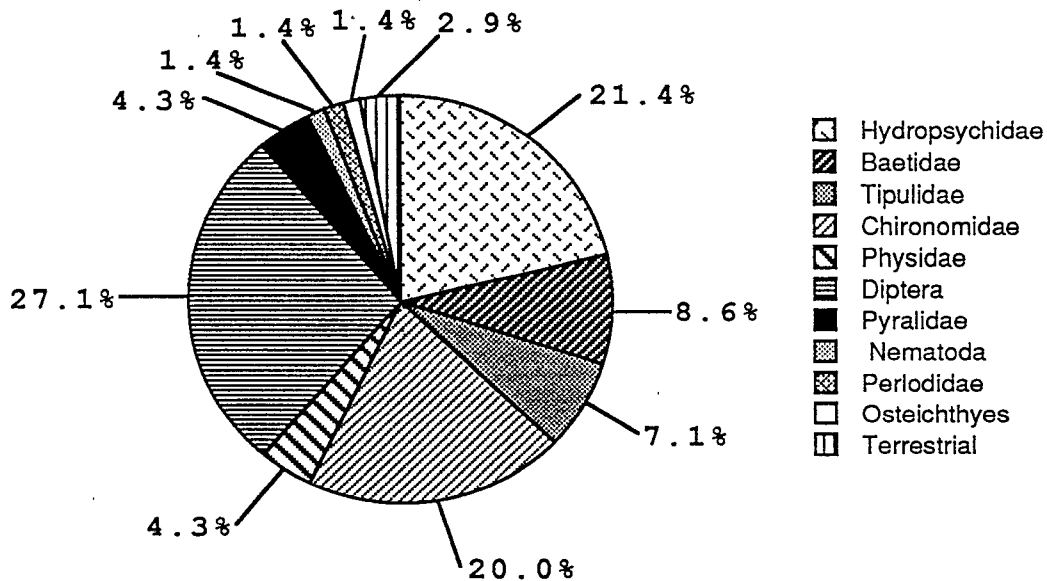
Rainbow trout, 4+ age class (n=2)



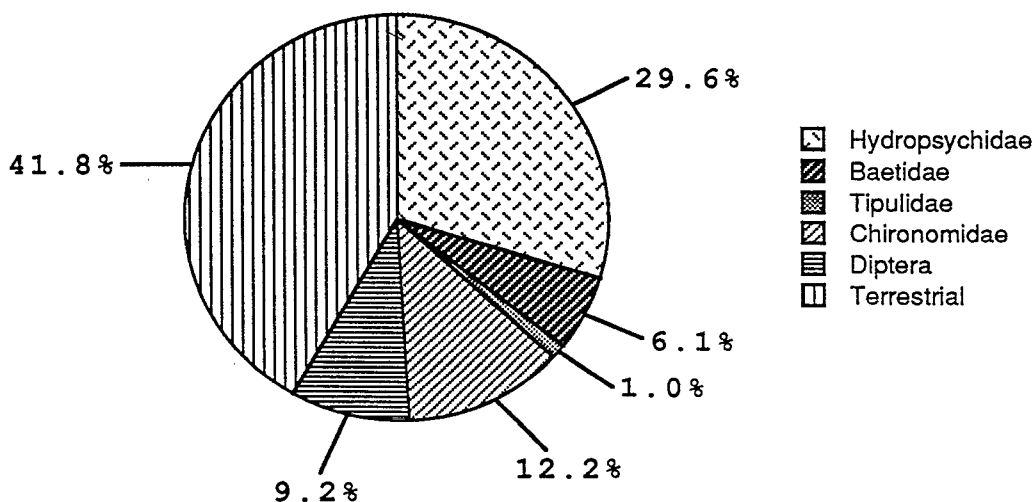
Appendix C (continued)

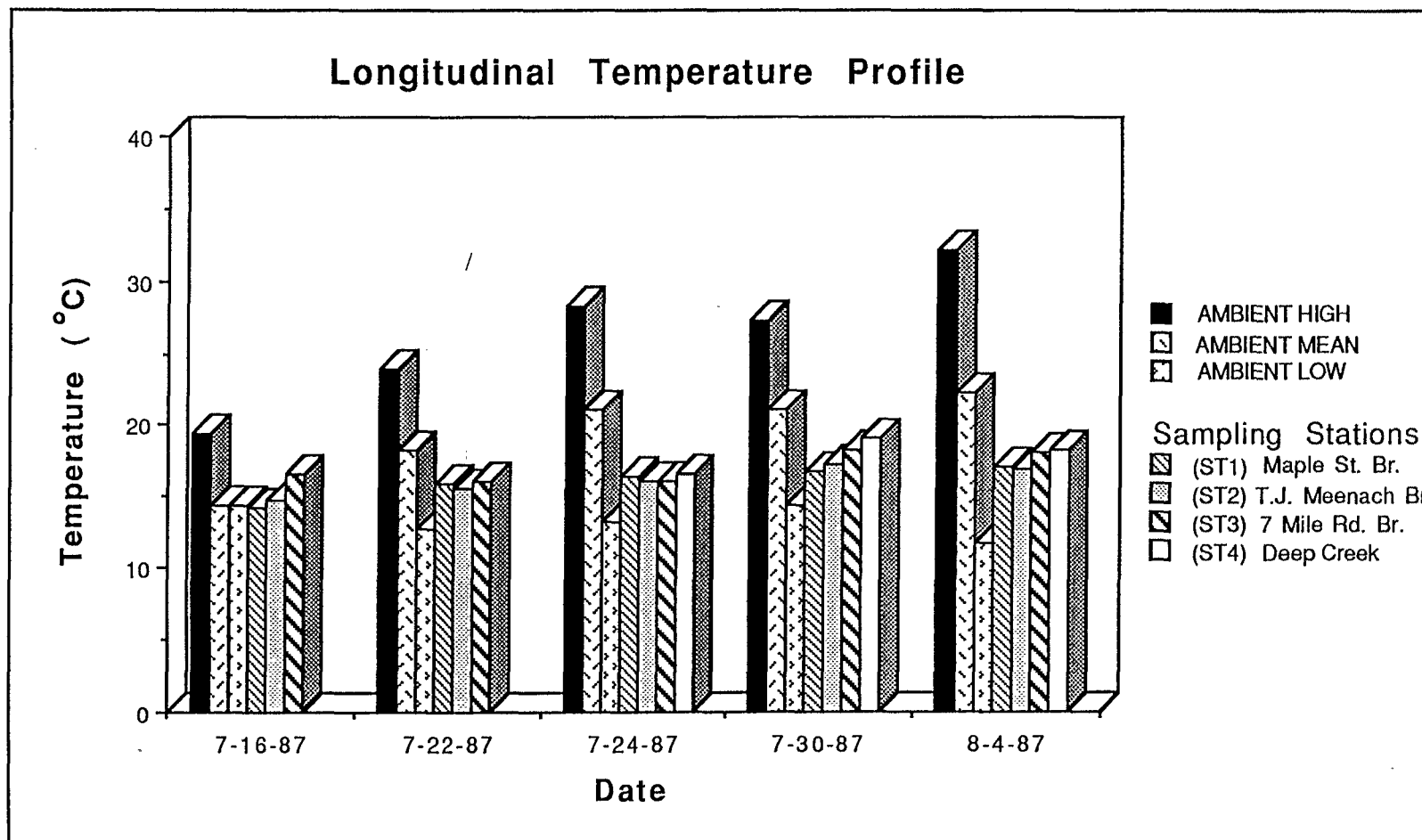
Summary of the diet composition by number for each age class of brown trout encountered in the lotic portion of the study area.

Brown trout, 2+ age class (n=2)



Brown trout, 3+ age class (n=3)

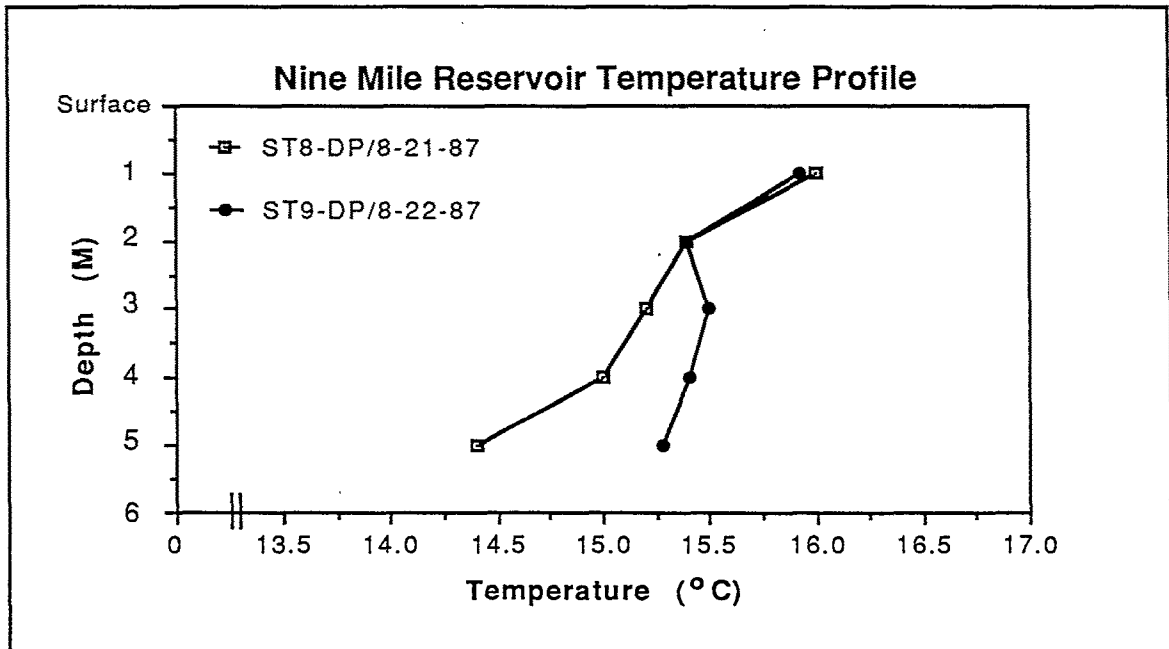




Longitudinal temperature profile for July and August from selected sites along the Spokane River and Nine Mile Reservoir.

Appendix D (continued)

Temperature profiles of deep station benthic invertebrate sites of Nine Mile Reservoir, 8-21-87 and 8-22-87.



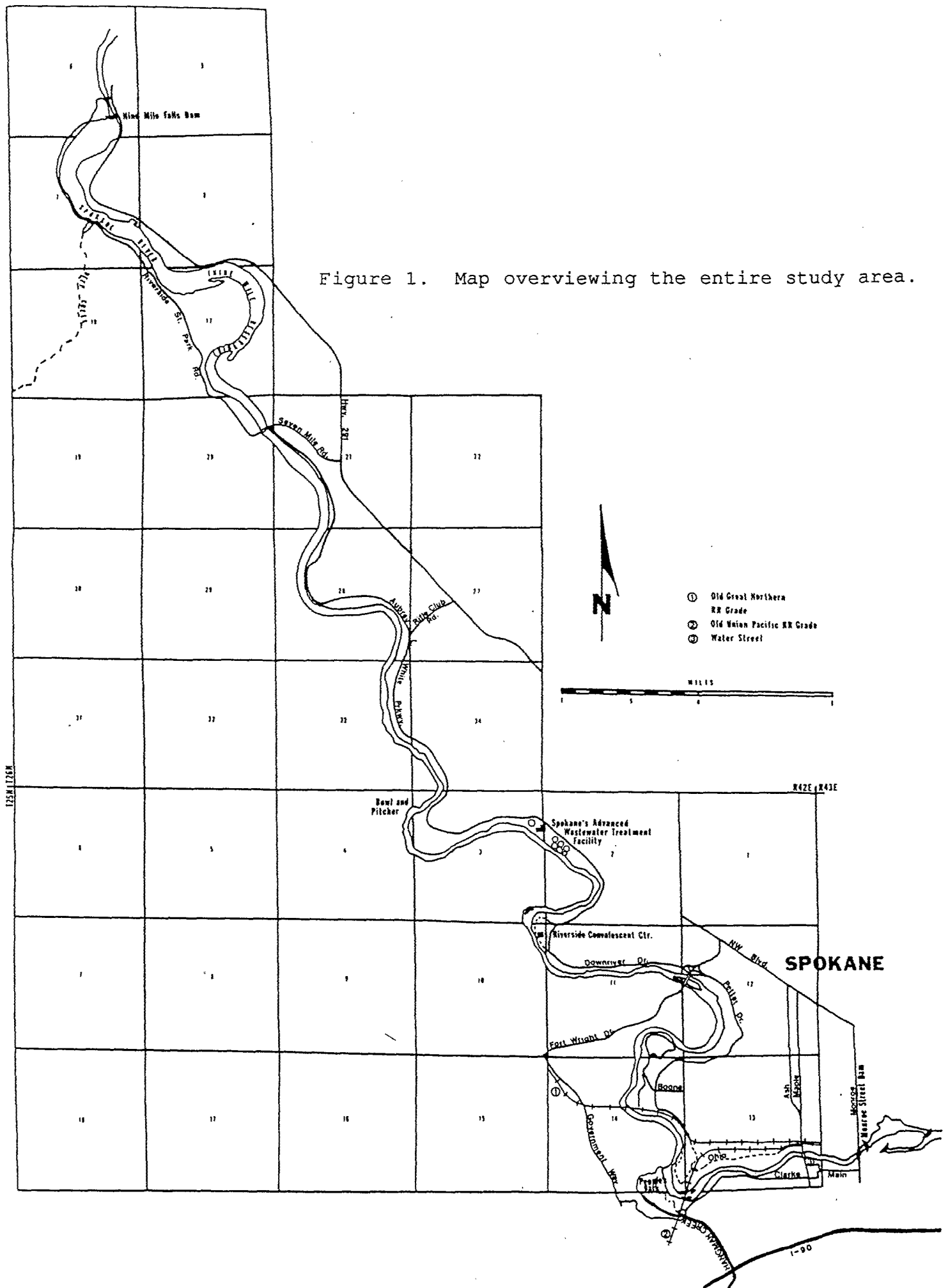


Figure 2. Map defining the benthic and zooplankton sampling stations.

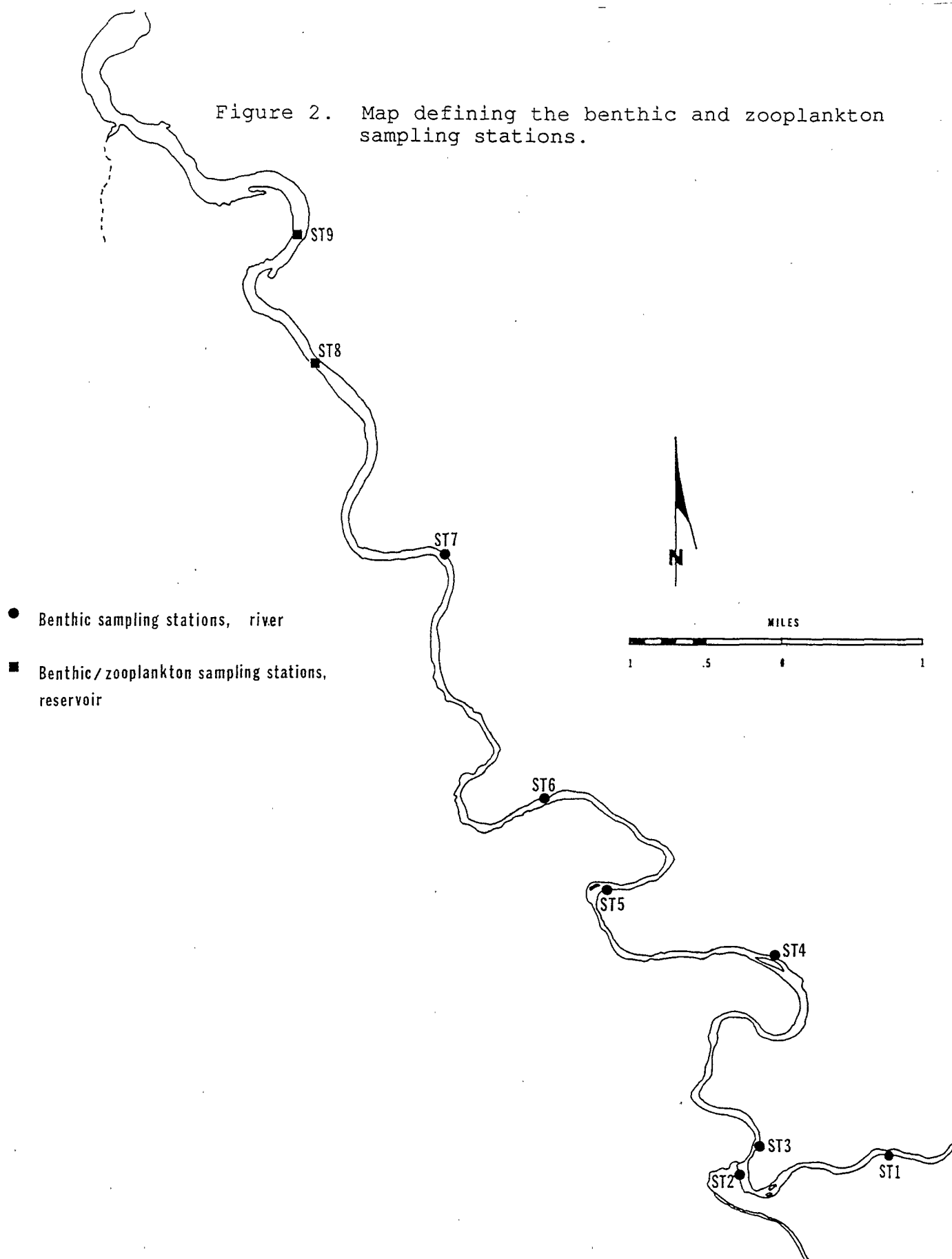


Figure 3. Reaches of river measured to determine pool-to-riffle ratios (darkened areas represent reaches measured).

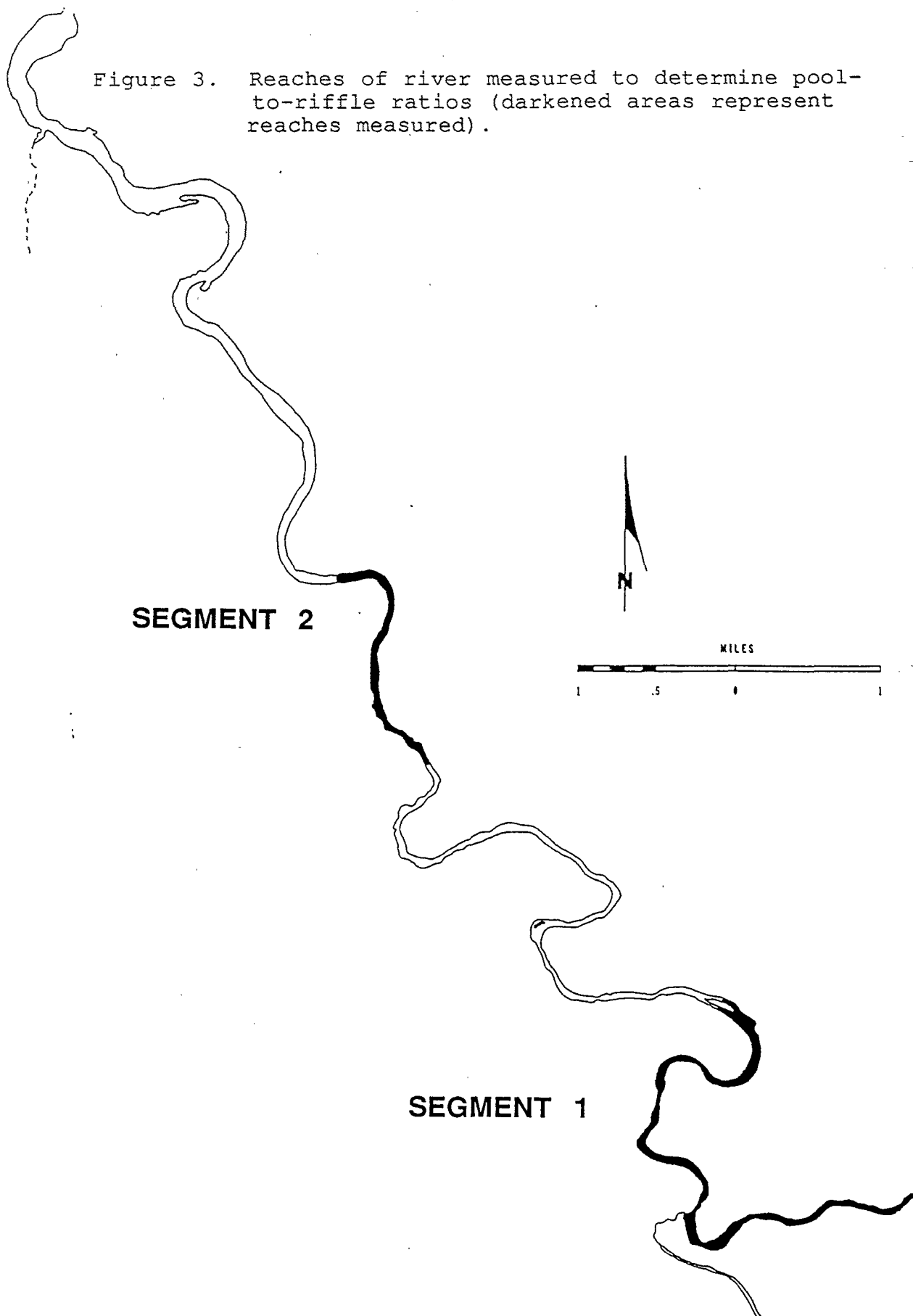
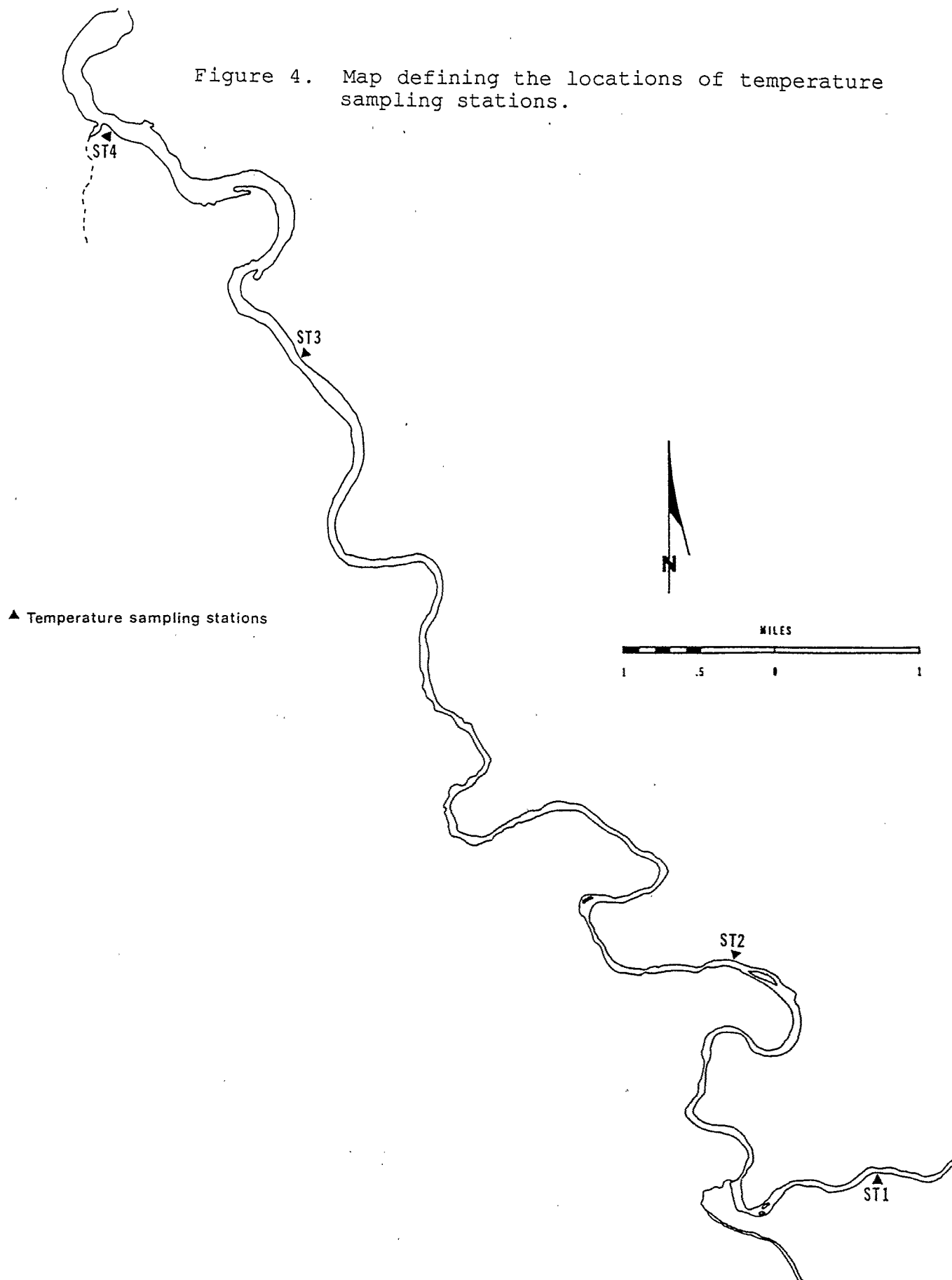


Figure 4. Map defining the locations of temperature sampling stations.



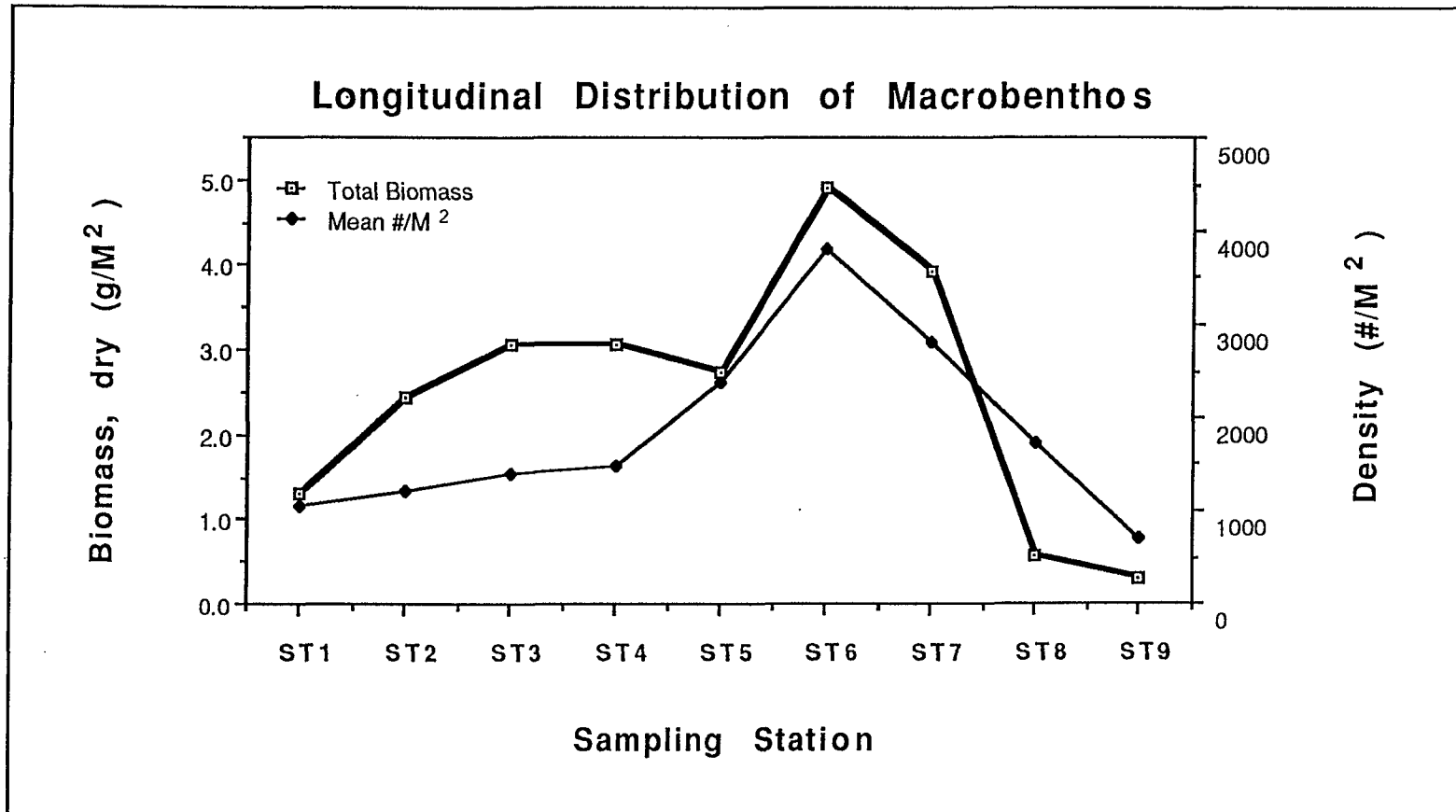
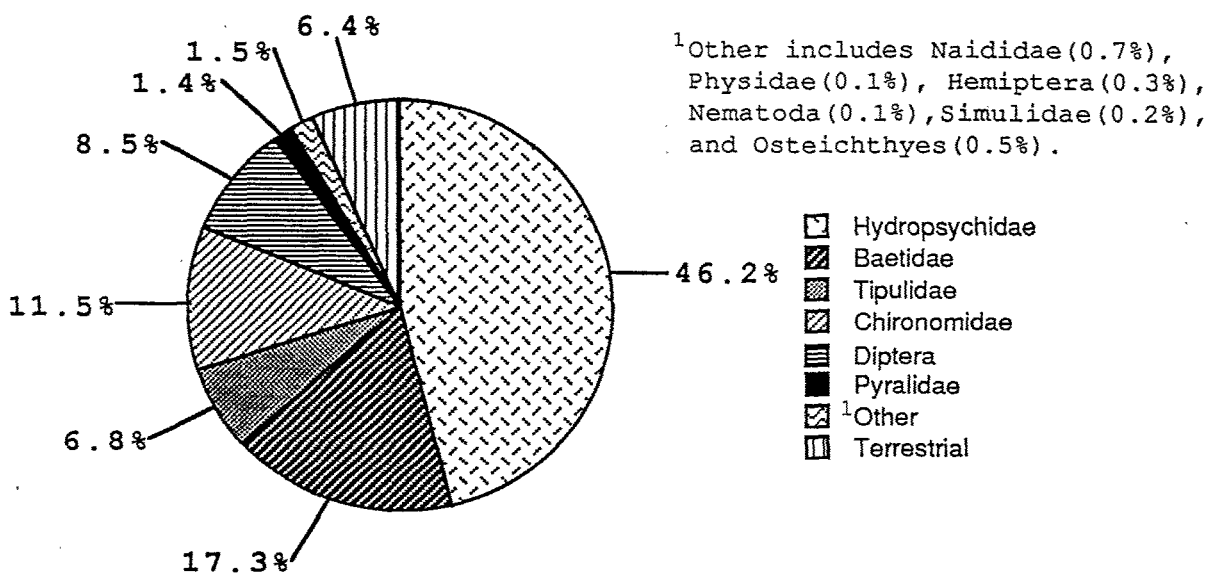


Figure 5. Longitudinal distribution, mean numbers/sq.M and grams/sq.M, of macrobenthos by sample station in the lower Spokane River and Nine Mile Reservoir from samples taken between 6-29-87 and 8-22-87.

Figure 6. Summary of the combined diet composition by number for all age classes of salmonids encountered in the lotic portion of the study area.

Rainbow trout, all age classes (n=14)



Brown trout, all age classes (n=6)

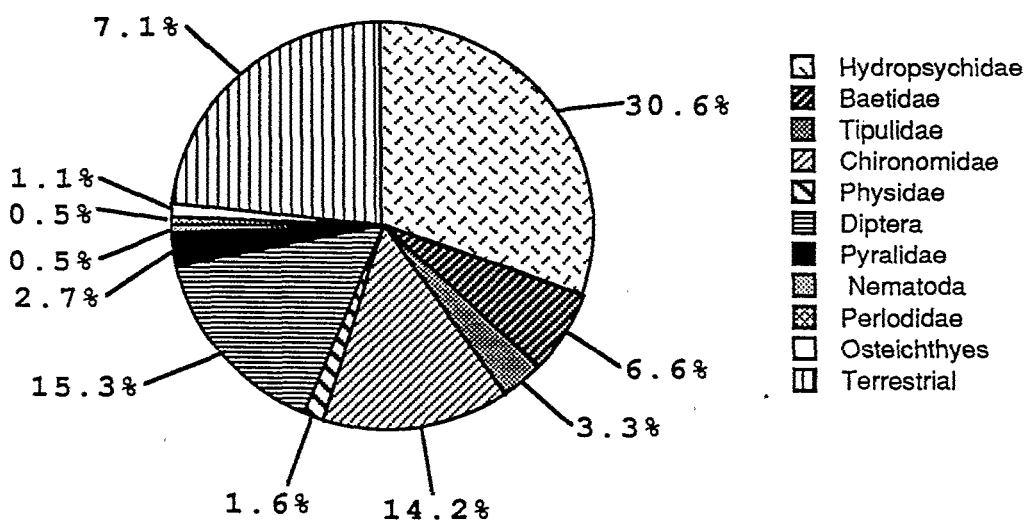


Figure 6. (Continued)

Mountain whitefish, all age classes (n=3)

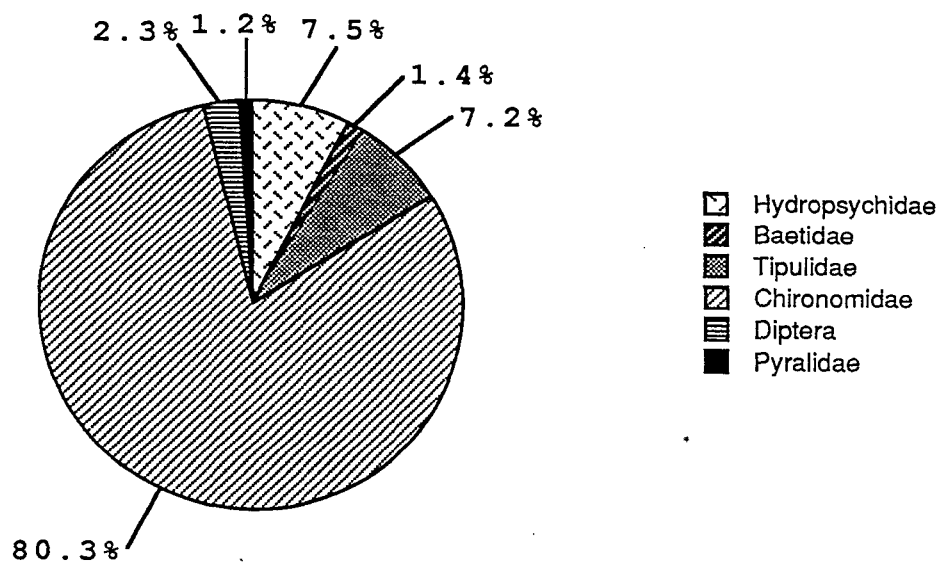


Figure 7. Summary of the diet composition by number for 2+ age class brown trout encountered in Nine Mile Reservoir.

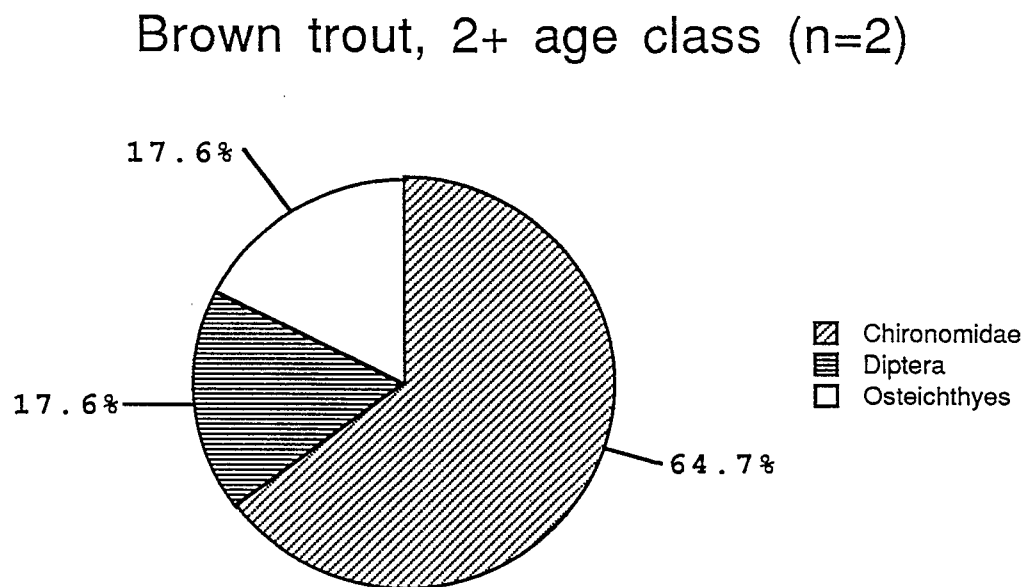
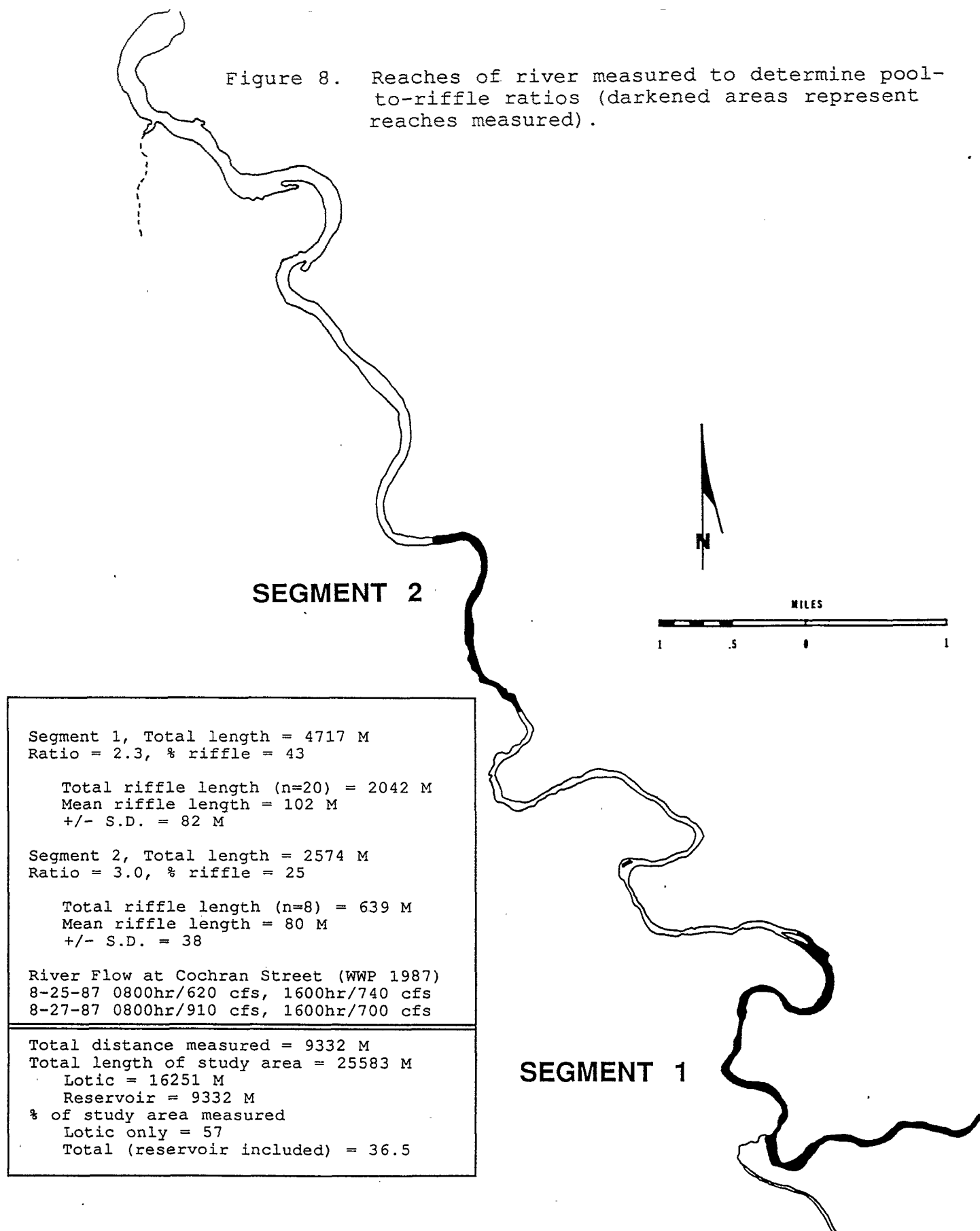


Figure 8. Reaches of river measured to determine pool-to-riffle ratios (darkened areas represent reaches measured).



ERRATA

DOCUMENT: Kleist, T.R. 1987. An evaluation of the fisheries potential of the lower Spokane River, WA: Monroe Street Dam to Nine Mile Falls Dam. Final report submitted to the Wahington Water Power Company and the Washington State Department of Wildlife. 60 pp.

Page 6 reads: Table Number
Should read: Figure Number

Page 8, second paragraph reads: (determined at a flow of 2200 cfs (USGS 1987).
Should read: (determined at a flow of 2200 cfs) (USGS 1987).

Page 9, fifth paragraph reads: (Weber 1973; Platts, et al).
Should read: (Weber 1973; Platts, et al).

Page 11, first paragraph reads: nearest millimeter, (Weber 1973)
Should read: nearest millimeter (Weber 1973),

Page 14, third paragraph reads: the area and a map wheel were one
Should read: the area and a map wheel where one

Page 15, fifth paragraph reads: who made the same conclusions
Should read: who made similar conclusions

Page 16, second paragraph reads: Bosmina sp. (4.14/L), and nauplii
Should read: Bosmina sp. (4.14/L), nauplii

Page 17, second paragraph reads: 0.92 for all species considered.
Should read: 0.92 for all species considered and 0.73 for trout species only.

Page 17, fourth paragraph reads: and one game fish (yellow perch)
Should read: and one gamefish (yellow perch)

Page 18, sixth paragraph reads: Baitidae and chironomidae were the next
Should read: Baitidae and Chironomidae were the next

Page 19, second paragraph reads: Terrestrial insects accounted for 7.1% of

Should read: Terrestrial insects accounted for 23.5% of

Page 19: Paragraphs 5 and 6 should not be separate.

Page 23 second paragraph reads: having ratios as low as 0.4:1 have been

Should read: having ratios as low as 0.4:1 have been .

Figure 6, Brown Trout, all age classes (n=6) reads: 7.1% Terrestrial.

This does not coincide with the porportion of the pie wedge.

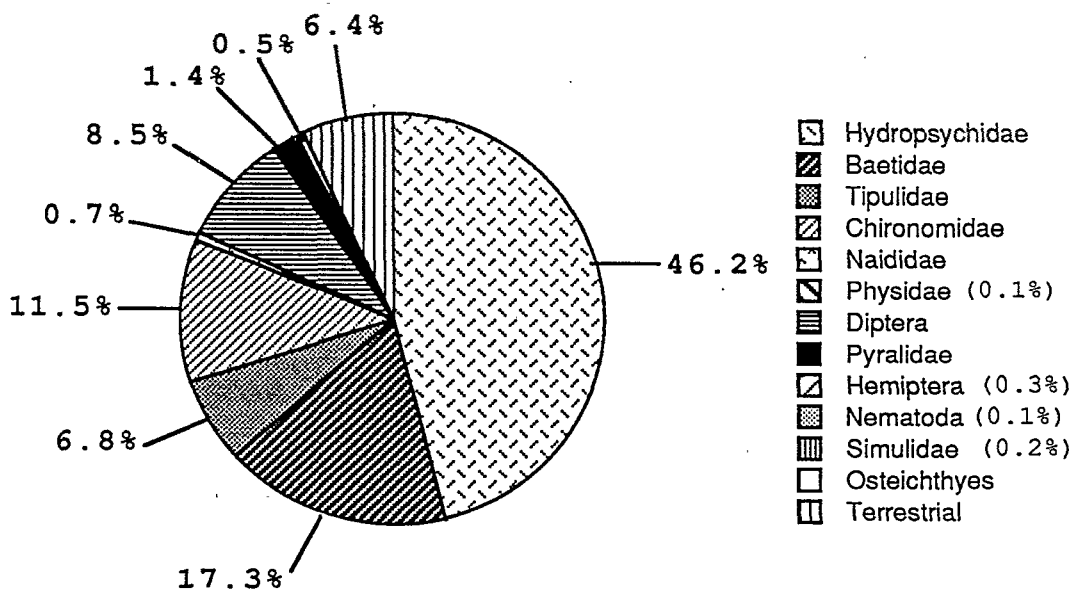
Should read: 23.5% Terrestrial.

This does coincide with the porportion of the pie wedge. see enclosure.

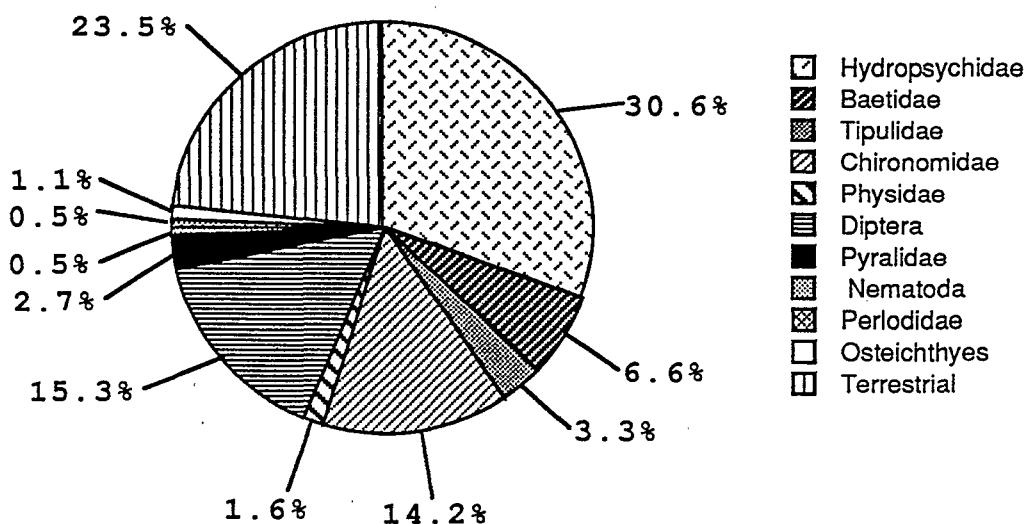
Figure 6

Summary of the combined diet composition by number for all age classes of salmonids encountered in the lotic portion of the study area.

Rainbow trout, all age classes (n=14)



Brown trout, all age classes (n=6)



17 December 1987

Roger,

How is everyone at the office? Please tell everyone hello for me. It looks like I'll be moving down to the Walla Walla area sometime around February. I just accepted a Wildlife Biologist 3 position with the state this week, but will be spending December and January in Cheney to complete the thesis. In fact, you may be aware of the work that the position involves. The work incorporates several agencies within different sub-basins of the Columbia River that will be working to develop supplemental management plans for the areas' anadromous fish stocks. Much of the work will resemble what myself and others did for the upper Columbia River.

The jist of this letter was to let you know of the errors that I have found in the report and to let you be aware of some additional input. I've done a few comparisons and talked to an invertebrate ecologist about the lower Spokane River benthic populations. While the overall numbers and biomass appear quite pronounced, the distribution is somewhat unbalanced and suggests community instability. However, we sat down and estimated the number of species and relative proportions that constitute the benthos so as to run a diversity index. The results suggest a rather high diversity which, in turn, suggests community stability. This information may only confound matters, but I thought you may be interested. As the population of fish currently stands, this is probalbly not of great concern. However, should management attempt to substantially increase populations, problems may arise.

That about wraps everything up. Thanks for the opportunities you provided this past summer, it has paid off. Wish everyone a **Merry Christmas** and a **Happy New Year**.

Sincerely,

Todd Kleist

P.S. The seminar of the Spokane River data ^{went} ~~was~~ pretty well, although an awful lot to cram into 15 minutes.